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Classroom Response Systems: Does Instantaneous Feedback Affect Students' Knowledge and Self-Efficacy in a Secondary Science Course

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CLASSROOM RESPONSE SYSTEMS: DOES INSTANTANEOUS FEEDBACK AFFECT STUDENTS' KNOWLEDGE AND SELF-EFFICACY IN A SECONDARY SCIENCE COURSE

by

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ABSTRACT

Technological advancements have enabled educators to bring excitement in student success with instantaneous feedback utilizing classroom response systems (CRS). A quantitative, quasi-experimental research design was used in this dissertation research to build a comprehensive understanding of the impact of instantaneous feedback with student knowledge and student self-efficacy. The purpose of this study was to illuminate the benefits of instantaneous feedback and student self-efficacy with incorporation of CRS in a secondary science course. Statistical analyses were conducted with quantitative formative scores, summative test scores, and self-efficacy questionnaire results prior to the incorporation of CRS, and perceived self-efficacy questionnaire results after experience with CRS

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DEDICATION

I did it daddy.

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CHAPTER I- INTRODUCTION

Technological advancements have enabled educators to bring excitement in student success with instantaneous feedback utilizing classroom response systems (CRS). Throughout extensive professional experience, the researcher has witnessed many students excel with science concepts within the classroom setting. Efforts to assist students have included practicing research based classroom management techniques such as clear, simple rules and expectations (Parsonson, 2012), implementing effective instructional methods such as presenting new material in small steps with student practice after each step (Rosenshine, 2012), and incorporating technology to maximize learning benefits such as CRS (Middleditch & Mondrot, 2015). Classroom management techniques have been influenced by respectful, consistent practices. Instructional methods that maximize learning while managing time limitations are the most favorable. However, technological advancements have enabled educators to enhance their educational strategies utilizing CRS (Costley, 2014).

The implementation of CRS magnifies the phenomenon of beneficial technology as the most successful form for a classroom setting, even more so than laptops or computers, for several reasons (Deal, 2007). CRS are a group of handheld devices that allow students to respond to teacher generated questions via, most commonly, multiple choice answers. These devices may provide immediate feedback and be transmitted to a graphic display viewed by teacher and/or entire class (Bruff, 2009). Implementation of this form of technology seems boundless in its benefits for teachers and students, including affordability, dependability, durability, and ease of use (Herold, 2016).

CRS is the most affordable, versatile technological tool within the educational setting. Some educators would argue that laptops are the best technology advancement in education, but limitations of cost and accessibility hinder an ideal integration. CRS average approximately $2,000 for a set of 32 clickers, including instructor tablet or remote, and the appropriate software package with computer receiver (Learning Services, 2018). Additionally, individual remotes can be purchased and electronically linked to existing systems to accommodate large classes or replace damaged individual clickers. It would be an unrealistic expectation to outfit thirty-two students with tablets or laptops around the same budget restraints, including the ongoing software updates and constant threat of computer viruses.

Another advantage for the versatility of CRS as the best technological tool within an educational system is its independence. As an independent system, internet access is not necessary for effective integration with students. The receiver can collect information from each clicker to be evaluated by teacher view. Another option is to display the collected responses as a graphic the teacher can share with the class if desired. Laptop and tablet programs are often innovative and educationally beneficial for students (Zheng & Warschauer, 2016). However, many educators have often experienced difficulty with dependable web connectivity. Many school districts under their own budget restraints have either limited or outdated bandwidth limits for dependable and effective educational use (Herold, 2016).

Very little detailed training is necessary for successful incorporation with CRS with students. These digital natives are quick to adapt with the basic, simple keypad system featuring four arrow keys above a simple ABC keyboard with a LCD screen. The

plastic casing enables durability for the occasional drop onto typical tiled flooring common in educational settings. Battery use is efficient with power save mode, and there is no worry for tangled, frayed, or lost cords necessary for charging. Entangled, knotted cords are a common problem many educators have encountered with classroom sets of laptops housed in carts for sharing. Classrooms are also not typically outfitted with thirty plus outlets for charging a class set of laptops, creating a safety hazard of multiple power strips littering the classroom floor.

Confidentiality is difficult to accomplish within a classroom setting, but CRS provides anonymity with students. Students can answer social questions without personal identification, allowing sensitive or controversial survey answers to be shared among the entire class without knowledge of how each student responded. This is a powerful educational feature with CRS. Classrooms with a CRS possess a unique freedom for student expression without compromising confidentiality.

This form of technology has prompted a variety of research featuring different variables within the educational community. Studies featuring CRS have been conducted within post-secondary settings. CRS have been linked to increased student attendance, engagement, motivation, peer instruction, subject matter retention, grades, and even confidentiality (Mahon, 2012). Many studies have overlapped with attitude questionnaires to measure amenity, convenience, and enjoyment with student use (Mahon, 2012).

Published studies have reported how student engagement increases with teacher implementation of CRS within a classroom setting (Trees & Jackson, 2007). One example of a recent study concerning student engagement included a survey of more than

two thousand post-secondary students. Survey items included eighteen different statements with a five-point Likert scale. Results of the student survey items indicated to the authors a validation of student engagement in coordination with the implementation of CRS with student activities (Trees & Jackson, 2007). Therefore, it is a logical conclusion that CRS within a classroom increases student engagement. But student engagement is not the only benefit with CRS in classroom settings.

While engagement is a highly desirable outcome with student performance, only the most basic incorporation of CRS has measured success. Studies have compared classes with and without clickers utilized during summative assessments (Bruff, 2018). Results of these studies have demonstrated that classrooms with clickers have higher assessment scores than classrooms without CRS integration. However, this is a very limited integration and other studies have addressed more versatile uses of CRS within a classroom design.

Retention of subject matter has been documented with a more integrated role of CRS with more than just end of unit, summative assessments. Studies have demonstrated that when CRS is integrated with PowerPoint presentations, these CRS activities have resulted in increased assessment scores with the same content (Gauci, Dantas, Williams, & Kemm, 2009). Other studies have investigated more creative integrations of CRS within a classroom setting. Games that have incorporated CRS have also demonstrated gains in student achievement (Rouse, 2013).

As of 2012, an estimated 30% of schools within the United States have incorporated CRS within classrooms manufactured by eighteen different companies, thus providing many opportunities to enhance the educational experiences of teachers and

students (Mahon, 2012). The influx of this creative technological tool has led to many research studies and professional conversations (Herold, 2016). Colleagues within my own school district have elected to disable the instantaneous feedback feature with student clickers or don't possess the option of providing their students with instantaneous feedback, sparking professional curiosity.

An extensive search of educational studies has demonstrated many benefits to include student attendance, engagement, motivation, peer instruction, subject matter retention, grades, and even confidentiality (Center for Educational Innovation, 2018). Berry (2009) featured instantaneous feedback feature with post-secondary nursing students and its benefits in a distance learning environment, but most reviews have not revealed the instantaneous feedback feature as a constant variable with these educational viable studies. Additionally, researched studies have been conducted with post-secondary settings, rather than secondary educational settings.

One example of post-secondary study demonstrated positive student evaluations and achievement that included instantaneous feedback within lecture format in a post-secondary physiology setting (Gauci et al., 2009). Also, Rouse's (2013) post-secondary gamification study included teacher providing correct answers with game format questions, but didn't clarify if the instantaneous feature was also employed. Dangel and Wang (2008) also collected results of many post-secondary studies to correlate the benefits and depth of student learning with integration with CRS, thus demonstrating the saturation of studies within the post-secondary environment.

Effective, timely, and relevant feedback is essential for gaining knowledge of new concepts with all students, not just in the post-secondary environment (Stenger, 2014). Time restraints and teacher-student ratio are common obstacles that hinder the opportunity for timely and relevant feedback within a secondary education setting. A feature with some CRS enables instantaneous feedback once an answer is processed via software interface. Incorporating instantaneous feedback feature with this technology may demonstrate gains with intrinsic self-efficacy then directly resulting in concept knowledge gains for students. However, little is known about the relationships between the CRS feature of instantaneous feedback and other variables such as self-efficacy and achievement in secondary science setting. There is a clear need for systematic research to investigate these relationships.

This quantitative study will address feedback opportunity, self-efficacy, and concept knowledge. A unique feature of this design is that different forms of quantitative data will be collected to support the predicted results. In this study, feedback will be used to test the theory of behaviorism that predicts that instantaneous feedback will positively influence student knowledge in a secondary education setting (Stenger, 2014). The self-efficacy questionnaire will explore self-efficacy gains for students at a secondary education setting as each student receives instantaneous feedback via their assigned clickers (Glynn & Koballa, 2006; Gaumer Erickson, Soukup, Noonan, & McGurn, 2016). The reason for collecting different forms of quantitative data is to further understand how timely feedback contributes to higher perceived student self-efficacy and increased success with concept knowledge.

Statement of Purpose

Effective, timely, and relevant feedback is essential for gaining knowledge of new concepts with all students, not just in the post-secondary environment (Stenger, 2014). Time restraints and teacher-student ratio are common obstacles that hinder the opportunity for timely and relevant feedback within a secondary education setting. A feature with some CRS enables instantaneous feedback once an answer is processed via software interface. Incorporating instantaneous feedback feature with this technology may demonstrate gains with intrinsic self-efficacy then directly resulting in concept knowledge gains for students. However, little is known about the relationships between the CRS feature of instantaneous feedback and other variables such as self-efficacy and achievement in secondary science setting. There is a clear need for systematic research to investigate these relationships.

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Research Questions and Hypotheses

Research Question One. Does instantaneous feedback via classroom response systems increase student concept knowledge with formative/summative assessments in a secondary science classroom?

Research Hypothesis One. Students who receive instantaneous feedback via classroom response systems during formative/summative assessments will demonstrate a statistically significant increase in knowledge scores with formative/summative assessments.

Research Question Two. Does instantaneous feedback via classroom response systems increase student self-efficacy in a secondary science classroom?

Research Hypothesis Two. Students who receive instantaneous feedback via classroom response systems will demonstrate an increase with self-efficacy as revealed by Research Collaboration's Self-Efficacy Questionnaire results.

Research Question Three. Does instantaneous feedback via classroom response systems influence a correlation between self-efficacy and content knowledge in a secondary science classroom?

Research Hypothesis Three. Students who receive instantaneous feedback via classroom response systems will demonstrate a correlation between an increase in self-efficacy and knowledge as revealed by formative/summative assessment scores and Self-Efficacy Questionnaire results.

Definition of Terms

The following terms are defined as they are used in this study.

Behaviorism is an educational philosophy that require students to practice a skill or concept. This practice enables students to master the skill being taught. It is imperative that students master each concept or lesson taught before moving on to the next concept or lesson. Technology can be a great assistance to students when completing homework or practicing skills that have been taught (Stein, 2011).

Classroom response systems are a group of handheld devices that allow students to respond to teacher generated questions via, most commonly, multiple choice answers. These devices provide immediate feedback, which may be transmitted to a graphic display viewed by teacher and/or entire class (Bruff, 2009). Other names for this type of technology include Personal Response System, Student Response System, Classroom Performance System, Electronic Response System, Audience Response System, Electronic Voting System, and clickers (Science Education Resource Center, 2013).

Formative assessments are instruments that provide both students and teachers feedback on student progress toward an academic goal or concept. This check point provides feedback in an expedient form so teachers can adjust instruction for maximum effectiveness. Often these informal assessments are not scored and may be in several forms, such as written summaries, completed graphic organizers, student-teacher conferences, or quizzes (Derrell, 2015).

Instantaneous Feedback is a technological feature provided by classroom response systems that display an "X" if the student response is incorrect or a "√" if the student response is correct. The student must press the "send" button for the response to

be sent to the software program via the receiver before the feedback "X" or "√" is viewed on each individual student's clicker.

Self-efficacy refers to a student's belief about his or her capabilities to produce a designated level of performance. This may determine how students think, feel, and motivate themselves. Bandura identifies four major processes that influences self-efficacy to include cognitive, motivational, selection, and affective processes (1994).

Summative assessments are those generally administered at the end of a unit or course. This type of evaluation is often utilized to measure the mastery of a set of concepts and typically yield a specific score. Summative assessments commonly feature a narrow range of question types, including multiple choice, essay, and short answer (Derrell, 2015).

Delimitations

The results of this study are limited to the secondary science students who were enrolled in a southern, rural high school Zoology I and II elective class in the Fall 2018 semester. The participants were allotted class time for formative assessments, summative assessments, and self-efficacy questionnaire.

Limitations and Discussions

The results of this study are limited to secondary science students who elected to participate in zoology elective course during the Fall 2018 semester. These students all have previously taken biology and passed the required SATP biology state test prior to enrolling in Zoology I and II. These students were not composed of an equal distribution of genders, ages, ethnicities, or academic labeling.

Assumptions

The assumptions of this study are that participants attempted to answer formative and summative assessments as accurately as possible. Another is that participants thoughtfully and truthfully answered self-efficacy questionnaire questions.

Justification for the Study

The conception of this study resulted from a conversation with a colleague in my local district. He has also incorporated CRS within his classroom due to my enthusiasm with this technology. As we compared experiences, his comment of disabling the instantaneous feedback feature with his CRS due to concerns of test security seemed overly cautious. A later conversation with a different colleague revealed her CRS did not possess the capability of instantaneous feedback, a different brand of CRS. My observations are consistently positive with the instantaneous feedback feature with CRS. The search for measured evidence began from the result of these conversations.

This study filled a gap in the literature related to the significance of instantaneous feedback with concept knowledge and self-efficacy with secondary level science students. The results of this inquiry have the potential to affect the educational system at all levels. Students, class environment, teacher, school, and even possible improved educational programs may benefit from the gains with individual student content knowledge and self-efficacy. A vital component begins with student engagement.

Sun (2012) summarizes conditions that must be present and practiced in order for individual students to maximize engagement in any educational activity. These conditions involve clear goals, a balanced view between the challenge and their personal skills, and an immediate feedback loop. CRS provide an excellent technological tool for

individual feedback that allows students to possibly make adjustments for success, which in turn can provide an opportunity for increased self-efficacy; however, there are additional benefits for students.

Students who receive immediate feedback gain several educational benefits in addition to personal engagement and motivation. Educational benefits include how feedback evaluates understanding, promotes learning, and informs testing criteria for students. Immediate feedback can quickly identify specific problem areas for adjustment to increase student academic success. As individual students benefit, the entire classroom environment improves greatly.

A positive, supportive classroom environment is generated when students are engaged and involved in active learning activities. Other variables that characterize productive classrooms are those that provide relevant content, clear learning goals, feedback, and strategies to assist with student success. CRS that provide instantaneous feedback and integrated with activities with many opportunities for student success is a valuable component for a positive, supportive classroom environment.

Teacher to student ratio is often at a maximum level due to budget restraints and overcrowded schools. Teachers will benefit greatly with ease of record keeping for measured student academic achievement with CRS. More importantly, teachers can quickly and efficiently identify common misconceptions or misleading conclusions by student response frequency. A teacher that is able to adjust instruction quickly and efficiently maximizes their instructional time and efforts with students, which then also maximizes student learning.

As an affordable, durable, and reliable form of technology, most schools have limited budgets. Purchases should also be sustainable over an extended time period, in addition to being implemented with a large number of students. CRS, with an average cost of approximately $2,000, can provide individualized experiences with a large class size (Learning Services, 2018). Once benefits of this form of technology are documented in a secondary education setting, other teachers and secondary subjects can successfully incorporate this effective technological tool.

Statistically significant differences with student concept knowledge may motivate teachers to incorporate CRS with their pedagogical practices. Positive gains from this study could rationalize funding for CRS within individual classrooms. Finally, this study has the potential to inform future research, including studies involving other technological strategies to increase student self-efficacy and concept knowledge.

Summary

This chapter introduces this quantitative study by describing CRS, including tangible benefits of cost, implementation, and student performance. The research questions and hypotheses reflect the researcher's ambition to quantify the role of instantaneous feedback feature with CRS and potential increase with student self-efficacy. A definition of relevant terms, delimitations, limitations, and assumptions that are incorporated within this study are listed and clarified. Conclusion of this chapter discusses the justification of this study to include students, teachers, classroom environments, and educational programs.

CHAPTER II- REVIEW OF LITERATURE

Technology in Education

Technological advancements in education has mirrored the advancements in society to improve quality of the educational purpose. Starting with chalkboards in 1890, the Scantron system of testing, introduced by Michael Sokolski in 1972, allowed educators to grade tests more quickly and efficiently. Very soon after, more immediate response-type systems and the photocopier had become a standard. Technological advancements also reflected student population. United States Department of Education reports that high school enrollment was only 10% of the eligible population in 1900, but by 1992 had expanded to 95%. To meet the increased demands to measure student learning, teachers needed new methods of instruction and testing (Purdue University, 2018).

A Classroom Response System (CRS) in its earliest implementation in the 1960's is defined as "technology that allows an instructor to present a question or problem to the class; allows student to enter their answers into some kind of device; and instantly aggregates and summarizes students' answers for the instructor" (Mahon, 2012, p. 2). Other names for the present wireless systems include Personal Response systems, Audience Response System, Student Response System, Electronic Response System, Electronic Voting System, Classroom Performance System, or clickers (Calhoun, Chaudhury, Frost, Goffe, McGoldrick, Maier, & Simkins, 2018). There are 14 different companies that feature CRS available to the educational community. Qwizdom, the brand utilized by the researcher, has over 30 years of industry experience (Social Compare, 2018).

The basic components of a CRS include a software and a hardware system composed of a receiver and transmitters. The software often can be integrated with other programs such as PowerPoint, or as stand-alone displays. The data collected can be manipulated with spreadsheet software or even exported to learning management systems, such as Blackboard. The receivers typically utilize radio signaling via USB connection to collect student responses sent via handheld transmitters or clickers (Calhoun et al., 2018).

Well documented benefits have resulted in close to 30% of schools in the United States implementing CRS by 2012 (Mahon, 2012, p. 3). Pedagogical practices that have been identified as effective with CRS implementation include peer instruction, Assessing-to-Learn, Deliberate Practice, ConcepTests, Just-In-Time Teaching, Interactive Lectures, Cooperative Learning, and Interactive Lecture Demonstrations (Calhoun et al., 2018; Mahon, 2012, p. 4). A more appropriate feature of successful implementation of CRS should include why they improve student outcomes. Increasing opportunity to respond and the role of feedback in instruction are leading contributors for increased student learning (Mahon, 2012, p. 5). It is a feature of instantaneous feedback the researcher will measure in this study as it contributes to student concept knowledge.

Classroom Response Systems in the Classroom

There are several types of questions that may successfully incorporate CRS. They include, but are not limited to: recall questions, conceptual understanding questions, application questions, critical thinking questions, student perspective questions, confidence level questions, monitoring questions, and classroom experiments. Recall, conceptual understanding, application, and critical thinking questions all pertain to

measuring different cognitive levels of student knowledge or higher order thinking skills and relate to specific concepts within the classroom. Student perspective questions allow students to share possibly some confidential classroom information while maintaining anonymity in the classroom and allows for students to connect with concepts on a more classroom level. Confidence level and monitoring questions both may play a role in student self-assessing their progress toward mastery of a concept or throughout a project. Finally, classroom experiments may utilize CRS to gather data to illustrate study findings within a small setting (Bruff, 2018). There are many different types of activities that successfully incorporate CRS.

The integration of CRS within the classroom are only limited by the creativity and technology prowess of the instructor. Specific examples of classroom activities include: taking attendance, summative assessments, formative assessments, homework collection, discussion warm-up, contingent teaching, peer instruction, repeated questions, question-driven instruction, and "choose your own adventure" activities. Taking attendance is the most basic use of CRS for instructors in large, typically post-secondary, classroom settings (Bruff, 2018). However, there many classroom activities that utilize CRS in varied, effective means.

Summative assessments are an easy integration if your CRS allow for a self-paced mode while formative assessments are more effective tools to pace or modify instruction by collecting answers from students to measure comprehension during instruction, which may also be known as contingent teaching. Instructors may request students to enter homework answers into their CRS as a means for collecting homework. Posing a question at the beginning of a class session to spark or illustrate a misconception for

classroom discussion may also be called question-driven instruction. Often classroom activities with CRS may also incorporate student discussion, such as peer instruction and repeated questions (Bruff, 2018). There are a variety of rationales for incorporating CRS within a classroom setting.

The positive impacts of CRS include maintaining students' attention during lectures, promoting active student engagement, promoting discussion and collaboration among students, encouraging participation from all students, and creating anonymity among students. Instructor benefits include, but are not limited to: taking attendance, rapid grading, check for student understanding, and allows for instruction to quickly adapt to the immediate learning needs of the students (Bruff, 2018). Many of these impacts have been measured and documented with research studies within the academic community.

Student performance data collected during the Fall 2006 classes of nonmajors biology and Introduction to Genetics were analyzed via factorial ANOVA at University of Wisconsin–Whitewater. There was a significant difference in how the questions were answered, $p = 0.017$, between answers with clicker and nonclicker questions, $p = 0.007$ (Crossgrove & Curran, 2008). There was no statistical difference in student performance between questions from the two different courses, $p = 0.491$, and no statistical interaction between the course with which the questions were associated and whether the questions were based on concepts taught with or without clickers, $p = .655$. A factorial ANOVA also compared the average number of questions answered correctly with the Bloom category of question, $p = 0.02$. But this result was due to whether clickers were used or not, $p = 0.001$, and not due to the Bloom level of question asked, $p = 0.629$. This

suggested that students performed better, regardless of the difficulty cognitive level of question, due to using clickers (Crossgrove & Curran, 2008). This study did not reveal if instantaneous feedback feature was utilized.

One study, conducted by Gauci, et al. (2009) concluded that content-based questions answered by CRS during PowerPoint presentations significantly increased individual scores on following quizzes and tests with the same content. Additional research demonstrated how students using CRS in the classroom actually score higher on exams than students in classrooms without CRS. This same team of researchers also documented that student attendance was much higher in post-secondary introductory biology classes (Freeman, O'Connor, Parks, Cunningham, Hurley, Haak, Dirks, & Wenderoth, 2007).

A study conducted with an introductory post-secondary science class demonstrated a significant difference with students' ability to utilize critical analysis skills after integration of CRS. This study's methodology incorporated anonymous polled results from students during a lecture PowerPoint format explaining the components of critical analysis. There is no mention of instantaneous feedback to individual students during fifteen minutes of treatment. However, critical analysis skills that included implications and resources demonstrated a statistically significant difference with students who incorporated CRS with their instruction (Adams & Columba, 2014).

A qualitative study with post-secondary students from a variety of science classes cited several benefits related to CRS in classroom settings. Highest rated benefits included content comprehensions review, generation of classroom discussion, and

application questioning. The methodology in this study did include student viewed histograms of student responses, but did not include the opportunity for individual instantaneous feedback. The students also communicated the belief that CRS implementation did support or improve their classroom learning (Gok, 2011).

Results of a mixed method study reported no statistically significant difference in end-of-course assessments (Hales, 2017). The assessments were the English II Mississippi Subject Area Testing Program required for regular diploma program in Mississippi high schools. Scores from more than 1,400 tenth grade English students were compared by a two-factor analysis of variance (ANOVA). Experimental design compared teachers with CRS implementation in their classroom with teachers without implementation. Methodology did not describe any form of specific implementation in these classrooms or if instantaneous feedback was provided. Data results concluded no significant difference with English II SATP test scores (Hales, 2017).

A recent study included a sample of approximately 1,000 middle school students, specifically seventh and eighth grade science students from New York (Cohn & Fraser, 2016). The goal was to determine if CRS improved student perceptions of their classroom, their attitudes toward science, and their academic achievement. How the CRS were utilized in these classes were not communicated in this study. A one-way MANOVA was utilized to analyze five learning environment scales and student outcome scales, including achievement and enjoyment. Results revealed a very large difference of 1.17–2.45 standard deviations for seven learning environment, attitude and achievement criteria. This demonstrated a statistically significant value for the implementation of CRS in a middle school environment (Cohn & Fraser, 2016).

Another middle school study included approximately 100 seventh grade math students in Georgia (Dunham, 2011). These students were divided into four classes, two of which integrated CRS and two that did not. Four classroom units of pretest and posttests scores, in addition to, Criterion-Reference Competency Test results were used as comparisons. Methodology did not reveal the level of integration of CRS within the experimental classrooms. A two-factorial repeated measure of analysis of variance demonstrated no significant difference with pretest and posttest scores between the classes with CRS and classes without CRS. Additional analysis revealed no significant difference with Criterion-Reference Competency Test results. Discussion illuminated researcher's lack of experience with CRS (Dunham, 2011).

A common theme with reviews of the literature illustrate the lack of isolated variables associated with gains of CRS. Much of the research so far is not systematic enough to effectively evaluate convincing scientific conclusions about what causes positive benefits with systematic CRS use. Possible conclusions published illustrate alterations of teaching methods associated with CRS may influence or be solely responsible, rather than the single variable of the use of clickers. Additionally, a "Hawthorne Effect" may be responsible or influencing the outcome of these educational studies, skewing data due to the treatment of our student while they are currently test subjects when we use CRS, and this special treatment causes the measured improvements rather than the use of CRS (Caldwell, 2017).

Concept Framework

Teddlie and Tashakkori (2009) defined a conceptual framework as a "consistent and comprehensive framework emerging from an inductive integration of previous

literature, theories, and other pertinent information" (p. 39). They claimed that a conceptual framework has high heuristic value if it has the potential to generate questions or ideas that may lead to informative and valuable research studies. Figure 1.1 depicts a visual diagram of the conceptual framework for the present study. I developed the conceptual framework with the goal of relating the variables that are most relevant to the research questions.

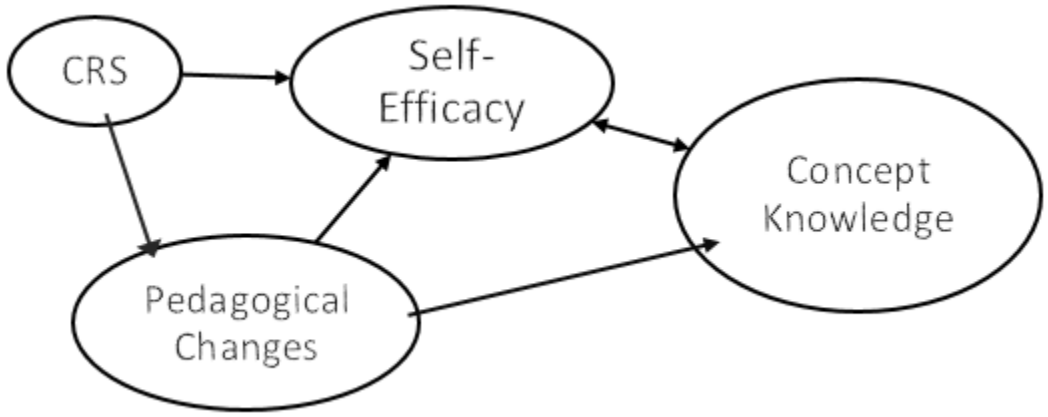


Figure 1. Conceptual Framework

Conceptual Framework relating classroom response system (CRS) use to self-efficacy and concept knowledge.

The conceptual framework for this study is comprised of four primary components: CRS, pedagogical changes that accompany CRS, self-efficacy, concept knowledge. The arrows in the diagram represent hypothesized causal or influential relationships between components. For example, successful CRS implementation will affect students' self-efficacy which will increase concept knowledge. Higher self-efficacy is believed to contribute to concept knowledge.

Educational Philosophy and Research

Educational philosophies influence how teachers shape their curriculum, pace, and delivery with students. A fundamental educational philosophy that greatly influences daily activities is Behaviorism. A common misconception of behaviorism is one of passive absorption of knowledge, but learning through experiences where the learner is actively engaged is more accurate. Emphasis is placed on the responses of the learner and validation of learning occurs by action. This modern instructional design lends even more validation when CRS provide the opportunity for students to receive immediate feedback (Reeves, 2010).

Some features of a Behaviorist classroom include direct instruction, lecture, positive reinforcement, and individualized instruction. Often a pattern persists of teacher modeling, student repetition, and teacher reinforcement. Instantaneous responses and grades, which are a strong factor of student performance reinforce the philosophy of Behaviorism (Flippen, 2014). Other fundamental, research-based educational reforms influence the classroom design of the researcher.

Science for All Americans (*SFAA*), the first Project 2061 publication, identified itself by realizing the value of science, mathematics, and technology as integral components to the education of today's students in order to be successful for our global challenges. This publication illustrates features that defines effective learning and teaching, especially important in science, mathematics, and technology educational settings (American Association for the Advancement of Science, 1990). The principles of learning and the principles of teaching are not isolated from each other, rather interrelated.

The principles of learning include a variety of vignettes for successful student achievement. These vignettes include that learning is not always an outcome of teaching, students are often limited in their depth of understanding with presented concepts from teachers. This should result with prioritizing valuable, limited concepts and skills for students to gain mastery, rather than brevity. Existing ideas of students also continue to influence what they learn, progressing from concrete to abstract concepts. Practicing concepts influence the effectiveness of learning. Student expectations and student feedback complete the basic fundamentals for the principles of learning outlined by the SFAA publication (American Association for the Advancement of Science, 1990).

Science for All Americans also illustrates how effective teaching should include specific principles for successful student achievement. First, teaching should be consistent with the nature of scientific inquiry. This includes questions about nature, engaging activities, collected evidence, historical perspectives, and clear expressions. It is also imperative that science teaching should reflect scientific values, counteract learning anxieties, extend beyond the school, and should take its time (American Association for the Advancement of Science, 1990). Timing is a delicate balance among state mandated curriculums, time schedule allotted for subject, and school cultured activities such as emergency drill practices, guest speakers, and mandated state accountability activities.

A second publication, *Benchmarks for Science Literacy,* recommends what all students should know and be able to progress toward science literacy. This report developed by a cross-section of practicing educators does not advocate any particular curriculum design, rather it is a collection of science literacy goals that may be organized

in different formats. This tool that is informed by research, avoids technical language, sheds partial light on how to achieve the published goals. This developing product specifics thresholds for achievement on the common core of learning to contribute toward science literacy (American Association for the Advancement of Science, 2009). While these publications reflect national and standardized classroom principles, the researcher also incorporates the 2018 Mississippi College and Career Readiness Standards for Science.

These standards, utilizing the K-12 Framework as a primary resource, include grade and course-specific standards for students in K-12 educational setting in Mississippi. Characteristics of these standards are designed to be relevant to real world skills. These skills are pertinent for student success with either college or careers to compete successfully in the global economy. The researcher incorporates the adopted standards from Zoology I and II for this study (Mississippi Department of Education, 2017).

Instructional Methods

Peer instruction (PI), introduced by Eric Mazur in 1991, is one example of a research-based pedagogy that has successful implementations with CRS. The typical format of a PI classroom includes a traditional lecture infused with conceptual questions targeting common student misconceptions. Following or even during the lecture, students are asked to answer a conceptual question individually and vote using either a flash card or a "clicker." If an incorrect answer is the most common within the classroom, the instructor then requests students to convince their neighbors why they choose the correct response. Following peer discussion, students are asked to vote again, and results shared.

The instructor may add features or share additional information to support the correct answer (Vickrey, Rosploch, Rahmanian, Pilarz, & Stains, 2015).

It is imperative to fully implement all components of the format. Either by time restraints or instructor choice, if an instructor eliminates the individual voting or peer discussion, studies have shown reduced learning gains. However, successful implementation of this pedagogy with 108 instructors from 11 different institutions, teaching 30 different courses have been measured. Ninety percent of these instructors measured positive, medium (between 0.30 and 0.70) normalized learning gains with peer instruction teaching methods. Not only direct learning gains have been measured, but also increased ability of knowledge transference, has been successfully documented (Vickrey et al., 2015).

It is valid to note a common reoccurring misconception with this instructional method. Results from several studies have demonstrated an occurrence in which students that viewed an initial bar graph displaying initial votes, were 30% more likely to change their initial response to the most common answer, regardless of their own confidence level. This bias was evident more often with more difficult concept questions and accounted for five percent of the learning gains measured between the first and final student vote (Vickrey et al., 2015).

Assessing-for-learning is also an integral instructional method that has proven to be successful with clicker implementation in the classroom. This pedagogical methodology includes teacher observation, classroom discussion, analysis of student work, and constructive reflection on student tests. Information gathered from formative assessment throughout the instructional unit is used to adapt teaching and learning to

meet student needs. This may include, but is not limited to, re-teaching, alternative instructional approaches, or additional opportunities for practice toward mastery. These strategies have been measured to show an improvement with student learning. Collected evidence demonstrates that incorporation of formative assessments is an essential component of classroom environment to raise standards of student achievement (National Institute of Education, 2014).

Key characteristics found within Assessment for Learning include sharing learning intentions with students, sharing the success criteria with students, involving the students in self and peer assessments, providing appropriate feedback, reviewing and reflecting on assessment information, and identifying the next steps. Learning intentions should not be confused with learning objectives, learning intentions are used to place greater emphasis on the process of learning. The benefits of sharing include increased student focus on purpose of activity by illustrating where the students need to concentrate their efforts. Studies have shown that when student are clear on what is expected, they tend to take ownership for their own learning (National Institute of Education, 2014).

Appropriate feedback should be constructive in nature and include particular characteristics. Assessment for learning clarifies appropriate feedback should be relevant, immediate, factual, helpful, helpful, confidential, respectful, encouraging, and tailored to meet the individual needs of the student. Some strategies for self and peer feedback that support Assessment for Learning include “two stars and a wish”, “plus, minus, what’s next?”, “warm and cool feedback”, “traffic lights”, and using models, exemplars, or rubrics (National Institute of Education, 2014).

Another instructional method that is often supported by CRS is deliberate practice. Ericsson and colleagues coined deliberate practice as a pedagogy with specific components to assist students toward mastery. Often this instructional method is correlated with specific motor skills, such as playing an instrument, improving how to pitch a baseball, or mastering a medical procedure. But the theoretical principles can be applied to any classroom setting (Heiman, Uchida, Adams, Butter, Cohen, Persell, Pribaz, McGaghie, & Martin, 2012).

Beyond basic knowledge, deliberate practice can be fundamental for students to achieve mastery. The key characteristics with deliberate practice include engaging learners in specific, defined, and focused tasks, providing specific feedback for correction of errors, and effectively evaluating learners to verify mastery. Once mastery of a skill is quantified, student can then advance toward more difficult or more complex skills (Heiman et. al., 2012). Specific feedback is vital for success with deliberate practice instructional methods and CRS is a tool that can assist instructors with this vital component.

Deliberate practices often may manifest instructionally as multiple-choice option activities that are teacher generated (Towns, 2014). A meta-analysis with eighty years of research has illuminated the optimal number of options with multiple-choice activities. A correct answer and two distractors are the best option for difficulty, discrimination, and reliability of an assessment. Increasing the options to four or five does not greatly improve the test item (Towns, 2014). Several other instructional pedagogical methods are integrated into the classroom.

ConcepTests is an instructional method that has also been referred to as "think-pair-share" exercises with some classroom settings (Steer, McConnell, Gray, Kortz & Liang, 2009). Most often, ConcepTests is the term applied to conceptual multiple-choice questions in which students may use electronic CRS to respond. A specific feature of these multiple-choice questions is to include answers with known preconceptions with students. These repetitive, formative exercises are utilized to illustrate the depth of understanding by students. Students consider the question and respond individually, then answer the questions again as a group (Steer et al., 2009).

Just-in-time teaching (JiTT) was developed in 1996 by a joint effort with Indiana University Purdue University Indianapolis (IUPUI) and the United States Air Force Academy to assist faculty and students with physic concepts, but has quickly been adapted for a wide range of subjects (Marrs & Novak, 2004; McGee, Stokes, & Nadolsky, 2016). Readily available internet access provides the launching pad for this modern day instructional method. Student reading assignments is not unique or innovative prior to a class meeting, but JiTT requires the completion of complimentary assignments related to pre-class assignment. These assignments are labeled as "Warm Up" and include specifics designed to illustrate student misconceptions, the level of student understanding, and identify prior knowledge (Marrs & Novak, 2004; McGee, Stokes, & Nadolsky, 2016).

A feedback loop is generated when classroom time, which typically possess time restraints, can then be spent allowing the instructor to address the misconceptions recorded by pre-class Warm-Up answers. Just-in-Time Teaching's label is derived from researched, documented cases in learning. Common student learning strategy evidence

suggest that students are primarily influenced by preexisting ideas or concepts of a subject. If their understanding is incorrect, this perception creates a stumbling block with the student's capacity to incorporate new, correct concepts with their knowledge base. Effective feedback loops with JiTT intersect these misconceptions and therefore provide students with opportunities to correct their misconceptions "Just in Time", opening the opportunity for learning to be corrected and acquisition of additional concepts (Marrs & Novak, 2004; McGee, Stokes, & Nadolsky, 2016). This is a primary goal of this pedagogical technique, but other benefits have been measured.

Other advantages with JiTT have been documented. Mars and Novak (2004) described how their Warm-Up's, titled "What is Biology Good For" provided clear, valid demonstrations of relevance with biological concepts in our society. Relevance is closely related to increased motivation when relevance is clear and apparent to students. Not only are summative assessment results positive, but also measures of improved student attitude, interactivity, and study habits have been strongly correlated with effective JiTT instructional methods. Positive gains in assessments often result in decreased attrition student rates and mirror by design, positive cognitive gains by students (McGee, Stokes, & Nadolsky, 2016). Just-in-Time teaching methodology seems recent in educational research, within the last thirty years, but that doesn't indicate that older pedagogical practices are not still advantageous for both teachers and students.

Interest in cooperative learning gained attention in the education community during the 1970s as research studies on the positive gains of social and academic benefits for students were published (Gillies, 2014). Key elements with successful implementation of cooperative learning involves student training in interclassroom skills,

small group sizes of four students or less, and strong encouragement for student expression of opinions to include possible solutions for problem solving. Meta-analysis of successful implementation with these key elements have resulted in higher student achievement with all types of representative groups, including such variables as subject areas, age groups, and range of cognitive challenges (Gillies, 2014). Each key element with cooperative learning must possess the following characteristics in order to be successful with this instructional methodology.

Strong interclassroom skills not only positively affect cooperative learning, but also students for building classroom confidence. Students in these classrooms should be able to actively listen to other students by sharing resources, taking turns with other group members, and accepting responsibility for their actions. These students also need to be sensitive to the other members of their group by not making disparaging comments, considering the other group member's perspective, and constructively critiquing the ideas of their group. Interclassroom skills of students are vital for effective group dynamics in cooperative learning environments (Gillies, 2014).

Establishing a state of positive goal independence with each group creates a momentum for group members to work cooperatively and effectively. Group members should understand that not only are they required to complete their part of the work assignment, but also to ensure that others do likewise by using their strong interclassroom skills. This creates a sense of accountability that emerges when individual members of a group dynamic accept responsibility for completing their part of the group assignment. Eleven previous studies have measured mean effect sizes ranging from 0.58 to 0.70 with successful cooperative learning environments in comparison to classrooms incorporating

competitive and individualistic learning. These results demonstrate a strong, positive cooperation promote greater productivity and higher achievement than competitive or individualistic modes of learning (Gillies, 2014). However, group processing is the last key element for successful integration of cooperative learning pedagogy.

Effective group processing includes each group member encouraging fellow members within their respective groups. This promotive interaction is evident when group members facilitate each other's efforts by actively listening, exchanging ideas, offering explanations, and providing constructive feedback. Benefits include peer explanations to assist concept understanding and improved student performance. Group processing also allows for self-evaluation of student performance and identification of future goals, which can be teacher or student-led discussions (Gillies, 2014). The final instructional method that can be successfully incorporated with CRS is the Interactive Lecture Demonstrations.

Developed by the Sokoloff and colleagues, The Interactive Lecture Demonstrations (ILDs) can incorporate CRS to transform a classroom from passive to active that engages students. ILDs include eight distinct events for any given topic or concept. The lecture begins with instructor demonstration without measurements. This first step may resemble a magic trick that is based upon a particular physical property or phenomena of the concept to be mastered by students. The students record individual predictions and then engage in small group discussions with nearby students. The teacher then solicits common student predictions from whole class. Once all the predictions are shared, students then record a second, final prediction. The teacher repeats the same demonstration, but with measurements. This methodology is completed when some

students describe the results as they relate in the context of the learning intention. The instructor or other students may share analogous features of the demonstration (Lakshminarayanan, 2011). Several observable practices are required to successfully implement ILDs.

A crucial point is the teacher's role to guide students toward important points, rather than lecturing to the students. The teacher may provide links to assist student toward mastery and use CRS to answer questions. The demonstration results are the source of knowledge and the entire Interactive Lecture Demonstration process may be described as a mnemonic, PODS. The acronym is representative for Predict, Observe, Discuss, and Synthesize, all tasks that are completed by students (Lakshminarayanan, 2011). Even though this methodology works well with physic concepts, with creativity, ILDs can be incorporated into other subjects.

Lecture in the Classroom

Research studies have demonstrated that even with the most entertaining, interesting lectures, the attention levels of the audience tend to drop after the first twenty minutes. Most effective lectures are broken up with multiple activities or rest periods to assist with maintaining attention levels with the audience or students. The efforts for making lectures as interactive are necessary for achievement of higher levels of attention and retention with students (Revell & Wainwright, 2009).

Revell and Wainwright (2009) have illustrated the necessary components for an effective, engaging lecture. A high degree of student participation and interaction is a vital component for an effective lecture. CRS enables instructors to pause for questioning generated by the teacher to allow for concept understanding or check for

common misunderstanding. Polling is another strategy fostered by CRS to engage students with the lecture format during instruction. Also, lectures are categorized as effective when key points are clearly identified and integrative links are illustrated with other areas of the course (Revell & Wainwright, 2009).

Perhaps a surprising conclusion of recent literature, is the third component necessary for engaging, effective lectures. The passion and enthusiasm of the lecturer plays a pivotal role in the success of an engaging lecture. The lecturer must be able to "bring a subject to life" to engage the audience. Therefore, student participation, clear key points, and passionate lecturers are the essential elements for an educational, engaging, effective lecture (Revell & Wainwright, 2009). PowerPoint software is among the most common instructional tools with a lecture format.

A research study conducted by Schmaltz & Enstrom (2014) illuminate how outstanding PowerPoint slides will not uplift a weak lecture, but certainly ineffective PowerPoint slides will certainly diminish the value of a strong lecture. This software can provide a valuable tool to enhance the educational goals of an instructor if properly implemented. Particular features were common with instructionally ineffective PowerPoint presentations to include font options, animations, text volume, and image quality.

Researchers found that students who attempt to read instructions in an unusual font that is difficult to read, were less likely to make the effort to read, and perceived the exercise as more difficult. These students also took more time to complete assignments. The font recommended as a safe option is Gill Sans. Another recommendation by Schmaltz & Enstrom (2014) regarding font choices is to present a variety and not

incorporate the templates provided by PowerPoint software. Placing text boxes over an effective graphic provides clarity in the text, however, be cautious as an instructor not to read the text to students (Schmaltz & Enstrom, 2014).

Images should be high resolution, without watermarks, and not include dated clip art. Animations are also considered dated and often distracting. Low resolution images, watermarks, dated clip art, and distracting animations and audio effects are considered unprofessional and should not be incorporated into a PowerPoint presentation. Effective presentations with clear font, minimal text, and clarifying high resolution images can prevent student distraction and facilitate a more effective lecture for the instructor (Schmaltz & Enstrom, 2014).

Class Time Schedule

Dills & Hernandez-Julian (2008) researched a small liberal arts college to determine the best time of day for class sessions for optimal learning. Their findings documented lower average grade point averages for morning courses relative to afternoon and evening courses. The variable of class meeting frequency correlated to time of day for class sessions. Students achieved higher grades in a class that not only met later in the day, but also met more often during the week. Multivariate regression analysis of this relationship demonstrated a statistical significance in grade point averages among students in morning classes versus students in afternoon or evening courses (Dills & Hernandez-Julian, 2008). However, this was a post-secondary institution with older students.

Another study conducted in California involved over two million students from sixth to eleventh grade. This study included many variables to determine the optimal

time of day for maximum educational benefit. One conclusion is that some math classes taught in the morning demonstrated an increase in student test scores and grade point average. Other data analyses resulted in no clear systematic differences in the time-of-day effect between gender, student age, high- and low-educated parents of students, or low- and high-performing students (Pope, 2016).

Pope (2016) proposes the time-of-day effect may be caused by changes in students' learning ability, teachers' teaching quality, or student attendance. Even though the circadian rhythm has been documented to experience its peak later in the day for adolescence, the school day is lengthy. Studies involving extended work hours have documented diminished work quality, illuminating reduced stamina. It is interesting to note that time-of-day on the performance of laboratory and field tasks varies drastically, not influencing the productivity of science skills. However, the general finding that productivity is higher in the morning than the afternoon allows for efficiency gains to be maximized before stamina is reduced (Pope, 2016).

Self-Efficacy

Self-Efficacy (SE) may be described among individuals within many settings including social, athletic, and academic. Academic Self-Efficacy (ASE) is defined as a learner's judgements about his ability to successfully reach or exceed educational goals. Recent meta-analytic studies have reported a moderate effect size accounting for up to nine percent of the variance with overall grade point average with post-secondary students in correlation with ASE beliefs. Other research suggests the mechanisms influencing ASE include individual classroomity, past performance experiences, and practice of self-regulatory learning strategies (Honicke & Broadbent, 2016).

Komarraju and Nadler (2013) performed a multiple regression analysis to demonstrate an eighteen percent variance in overall grade point average with self-efficacy, effort regulation, and willingness of students to seek academic assistance. These researchers concluded self-monitoring and self-regulating impulses are correlated to students who can achieve academically. These persistent classroom traits allow for high self-efficacy students to place higher priorities with academic performance and mastery of goals (Komarraju & Nadler, 2013).

Each of these variables is closely linked with the others, demonstrating a cascade effect. Students with high academic performance correlates with increased confidence which encourages the student to take greater responsibility for successful academic tasks. Also, students with a higher aptitude that have better academic performance and more positive evaluations report higher self-efficacy and less apprehension than their peers (Komarraju & Nadler, 2013).

Reported fluctuations in self-efficacy have mirrored student performance feedback. Unfortunately, they parallel, low achieving students report less confidence and high performing students report higher self-confidence. High performing students also report a greater value for their learning in a post-secondary environment (Komarraju & Nadler, 2013). Providing ample opportunity for student feedback with the CRS should influence their own perceived self-efficacy.

Within a secondary educational level, a study involving a distant learning environment measured a decrease of self-efficacy with low performing students and little to no change in self-efficacy with higher performing students. Discussions of within this study illuminated the possible variables that may affect self-efficacy to include

autonomy, clear expectations, goal specificity, balanced task difficulty, vicarious experiences, and effort regulation (Kim, C., Park, S. W., Cozart, J., & Lee, H., 2015). Komarraju and Nadler (2013) concluded that effort regulation was the controlling variable in regards to increasing self-efficacy in a post-secondary environment. A study of students within a secondary educational setting determined academic interest and intrinsic vs. external need for cognition were the largest two variables to influence academic self-efficacy (van Rooij, E. C. M., Jansen, E, P. W. A., & van de Grift W. J. C. M., 2017).

Summary

The review of literature attempts to provide a comprehensive background regarding this quantitative study. Technology in education, specifically CRS studies, are reviewed to provide an overview of successful gains with students. The conceptual framework attempts to provide a visual demonstration connecting instantaneous feedback with measured student knowledge and self-efficacy. Educational philosophy, instructional methods, and class dynamics address the researcher's pedagogical choices and implementation. Factors that influence student self-efficacy conclude this chapter.

CHAPTER III - METHOD

This chapter provides an overview of quantitative methodology the researcher used when conducting this study. The researcher described the setting in which the study was conducted and the characteristics of the participants. The researcher provided a description of the formative and summative assessments. Also, a description of the survey instrument chosen that measured student perception of self-efficacy pretest and posttest implementation of instantaneous feedback with CRS software. Finally, the researcher described the process of collecting and analyzing the data, including quantitative analysis of formative and summative assessment scores and quantitative analysis of perceived self-efficacy questionnaire results.

The present study sought to identify the relationships among classroom response system (CRS) feedback, self-efficacy, and concept knowledge with secondary science students. With this purpose in mind, the researcher tested three research questions to guide the study that reflected collected quantitative data from formative and summative student activities and students' self-efficacy perception questionnaire results.

The research questions were as follows:

Research Question One: Does instantaneous feedback via classroom response systems increase student concept knowledge with formative/summative assessments in a secondary science classroom?

Research Question 2: Does instantaneous feedback via classroom response systems increase student self-efficacy in a secondary science classroom?

Research Question 3: Does instantaneous feedback via classroom response systems influence a correlation between self-efficacy and content knowledge in a secondary science classroom?

Research Design and Data Analysis

Based on the research questions, a quantitative, quasi-experimental research design was the most effective in providing the best evidence for gains in student concept knowledge. The first research question involved comparison between quantitative variables, student concept knowledge scores without instantaneous feedback and knowledge scores with instantaneous CRS feedback. The second research question pertained to students‘ self-efficacy with instantaneous CRS feedback. The third research question correlated with the self-efficacy questionnaire scores with formative and summative assessment scores with CRS instantaneous feedback. Therefore, the researcher concluded that a quantitative study integrating quantitative data from student scores and self-efficacy questionnaire scores within the conceptual framework was the most productive research design to provide meaningful answers to all of the research questions.

The participants, including the instructor and students, were the same throughout the study. All students utilized CRS with all formative and summative assessments:however, the treatment of CRS instantaneous feedback, was only available to one class for two consecutive units. The treatment of CRS instantaneous feedback then was applied asynchronously to the other class for two consecutive instructional units. This continued for a series of twelve units spanning most of the Fall 2018 semester. This alternation among two different classes provided comparison without the

added variable of skill or ability levels. Instructor, students, formative assessments, summative assessments, instructional design and timeline were all constant to isolate and measured the effect of treatment, instantanous feedback, in gains of concept knowledge. Powerpoint presentations and student guided notes were teacher developed to correlate with 2018 College and Career Readiness Mississippi Science Standards for Zoology I and II (Mississippi Department of Education, 2017; Hickman and Roberts, 1994).

Statistical techniques were used to answer research questions and hypotheses. The dependent variables included formative assessment scores with CRS instantaneous feedback, summative assessment scores with CRS instantaneous feedback, and self-efficacy questionnaire results. Formative and summative assessment knowledge gains were measured as a raw score. Each raw score was summed and then converted into a single percentage score for the unit. The Self-Efficacy Questionnaire was obtained from Research Collaboration Surveys website and scored on a 100 point scale (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). The independent variables included student formative and summative assessment scores without the treatment of instantaneous feedback, school grade level, and gender.

Descriptive analysis of the data was conducted to determine mean and standard deviaton, which will then be used in further statistical analyses. An independent *t*-test was utilized to analyze statistically significant difference among formative and summative assessment scores from students with and without the treatment of instantaneous feedback with CRS. A paired sample *t*-test analyzed statistically significant difference in self-efficacy after the experience and treatment of instantaneous feedback with CRS. Data collection began after permission was granted from South

Mississippi school district's superintendent of education, south Mississippi high school principal, and The University of Southern Mississippi's Institutional Review Board. Parental consent and student assent was collected prior to data analyses.

Participants

The instructor began teaching secondary science courses in 1992 and zoological concept related classes have been incorporated with teaching assignments since 1993. Zoology I and II are life science electives available to all students after they have earned a biology Carnegie unit and passed required state mandated biology end-of-course exam as a regular education diploma requirement. Course selection choices were completed by students and their parent/legal guardians during the spring prior to the 2018-2019 school year scheduling.

The instructor incorporated the use of CRS with pedagogical practices in 2004 consistently incorporating the instantaneous feedback feature with many assignments. Throughout teaching experiences, instructor integrated CRS more frequently with many student activities throughout units of study including summative assessments. The instructor also upgraded the quality and use flexibility of CRS throughout teaching career.

Students from a South Mississippi K-12 school district were involved with this study. The district had an approximate population of 4,500 students. The district included only one high school with an approximate population of 1,300 students. District demographics included 88% white, 51% male, and 12% students with Individualized Education Plans. Ethnicity demographics described 88% of our student population as Caucasian, while only 12% is African-American, Asian, or Hispanic. The district is

described as rural with 61% of the high school population receiving federal assistance, either reduced or free lunch, indicating a low socioeconomic status.

The sample of students for this dissertation study was enrolled in two available elective Zoology I and II classes in the Fall semester of 2018, calendar dates from August 7, 2018 to December 20, 2018. Student assent and parent/legal guardian permission was obtained prior to data analysis and collected by an independent research assistant, another certified teacher at the same school. Participants selected for this study were those students who elected to enroll in a science elective, Zoology I and II. Student services randomly organized students into either class, block 3 or block 4. All students participated in study received treatment of instantaneous feedback with CRS, but with alternating instructional units. These two classes, scheduled after lunchtime included approximately a total of twenty-two students in each class, based on previous course selection surveys. Participants weren't excluded due to grade level, gender, race, or ethnicity.

Instrumentation

Materials during this study were the same for both Zoology I and II elective classes, including instructor and delivery method of instruction. Each student received identical instructional physical materials within the same timeline for units of study. Powerpoint presentations and student guided notes were teacher developed to correlate with 2018 College and Career Readiness Mississippi Science Standards for Zoology I and II (Mississippi Department of Education, 2017; Hickman and Roberts, 1994). Not only brand of CRS, but also frequency opportunities of use, was identical for all students. Formative and summative assessment raw scores generated by instructor were used to

measure concept knowledge. Self-Efficacy Questionnaire from Research Collaboration was utilized to measure student self-efficacy during study (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016).

Formative assessments were teacher-generated assessments during an instructional unit. Instructional units were constructed by the instructor incorporating the Zoology I and II competencies from the Mississippi College and Career Ready Science Standards that were coauthored, adopted statewide, and implemented during the 2018-2019 school year (Mississippi Department of Education, 2017; Hickman & Roberts, 1994). Previous experiences with teacher-generated assignments utilized in this study resulted with average student mean scores, representing a normalized distribution. Two or three of these assignments were distributed during an instructional unit of study for student completion using resource material after lecture including the same concepts. These assignments designed as deliberate practices were composed of twenty-five multiple choice questions, ranging from knowledge to application skill levels. Multiple choice options were four, reflecting literature recommendations (Towns, 2014). CRS was utilized with each formative assessment for recording of student responses.

Summative assessments were teacher-generated assessments at the conclusion of an instructional unit. Instructional units were constructed by the instructor incorporating the Zoology I and II competencies from the Mississippi College and Career Ready Science Standards that have been coauthored, adopted statewide, and implemented during the 2018-2019 school year (Mississippi Department of Education, 2017; Hickman & Roberts, 1994). Previous student experience with these teacher-generated assessments have resulted in average mean scores, representing a normalized distribution. These

assignments were composed of 40-50 multiple choice questions, ranging from knowledge to evaluation skill level. Multiple choice options were four, reflecting literature recommendations (Towns, 2014). Students completed these assessments without any instructional aides to measure mastery with unit concepts. CRS was utilized with each summative assessment for recording of student responses.

Bandura's (1986) self-efficacy theory guided the development for questions to measure student self-efficacy. Portions of the Science Motivational Questionnaire that referred to self-efficacy have also been mirrored in Research Collaboration's published Self-Efficacy Questionnaire, see Appendix H (Glynn & Koballa, 2006; Gaumer Erickson et al., 2016). This questionnaire is similar to Skill Confidence Inventory scale (SCI) which was written in a reading level appropriate for high school students and developed from Bandura's theory (Redmond, 2009). Reviewing additional resource material provided via the Science Motivational Questionnaire portions that directly related to self-efficacy provided additional confidence that Research Collaboration's published Student Self-Efficacy Questionnaire was appropriate tool (Glynn & Koballa, 2006; Gaumer Erickson et al., 2016).

Student perceived self-efficacy was measured utilizing Research Collaboration's published questionnaire. Review of literature has determined that positive self-efficacy increases when students possess the belief that their ability can grow with effort and also a perceived belief in their ability to meet specific goals (Glynn & Koballa, 2006; Gaumer Erickson et al., 2016). The questionnaire results were displayed on a 100-point scale while can be interpreted similar to grades, for example a score range betwee70-79 is average. This questionnaire was tested for reliability using Cronbach's coefficient alpha2

with results from more than one thousand, three hundred middle and high school students and was found to be highly reliable (13 items; $\alpha = .900$). When results of the questionnaire were converted to a 100-point scale, the lowest quartile ranged from 20 to 74 and the top quartile ranged from 93.5 to 100 (Gaumer Erickson et al., 2016).

The CRS that was utilized in this study is the Qwizdom Q6 classroom set of 32 handheld clickers with instructor tablet. Each student was assigned a numbered handheld clicker with LCD screen and four arrow keys above a simple ABC keyboard. The clickers are powered by two AA batteries. Students received a set of questions, either formative or summative assessment. Students answered formative or summative questions independently by selecting their response, either by selecting and pressing the appropriate ABC key or by using the up/down arrow keys to highlight student's response choice.

The student completed the answering process by pressing the "send" button on their handheld clicker. The radio frequency signal was transmitted to the receiver connected to the instructor's computer. The instructor had the capability of enabling or disabling the instantaneous feedback feature with students. If the instructor enabled the instantaneous feedback feature, students' handheld clicker displayed an "X" if the student response was incorrect or a "√" if the student response was correct. If the instructor disabled the instantaneous feedback feature, students' handheld clicker displayed "X/√" when their answer was sent electronically.

Procedures

Once approval was granted by The University of Southern Mississippi's Instructional Review Board, a South Mississippi school district's superintendent of

education, and a South Mississippi's high school principal, a presentation to students enrolled in two zoology classes to explain study occurred. The presentation concluded with a written description of study and informed consent letter to be signed by their parents/legal guardians and a student assent form signed by individual students. All students that returned signed letters were assigned a numerical code. Additional demographic data was collected from approved participants included grade level, ethnicity, and gender. Student numerical codes were used to replace student names on all data collected included formative assessment scores, summative assessment scores, and self-efficacy questionnaire results. Participants were able to withdraw from this study at any time without any academic or personal repercussions.

Subject confidentiality was a vital priority and protected by several safeguards. First, student individual identity was concealed by application of numerical codes. Assistance by an independent research assistant, a certified colleague within my local school, procured and secured student data in a locked file cabinet including parent/guardian and student permission forms, student names and their respective numerical codes, and student demographic data. Security was extended to password protected electronic files to protect student anonymity. The researcher was not aware of participating students until the conclusion of the Fall 2018 semester, December 20, 2018. The data collection process utilized student numerical codes in order to protect and prevent any identification with individual students or correlation of student responses with individual students.

The study spanned over the entire fall semester of 2018, from August 7 to December 20, with Zoology I and II competencies adopted from the 2018 Mississippi

College and Career Readiness Standards. Instructor was a coauthor of adopted competencies by the Mississippi Department of Education as a participant with Revision Task Force. Teacher generated formative assessments and summative assessments were utilized. Two or three formative assessments were designed as deliberate practice for mastery during the instructional unit after lecture sessions. Almost all units concluded with a teacher generated summative assessment. The instructor divided Zoology I and II competencies into thirteen separate units that were taught in a time period of an 18-week semester included 96-minute class length, block schedule format. Separation of Zoology I and II competencies are present in the following table (Mississippi Department of Education, 2017; Hickman & Roberts, 1994).

Table 1 *Zoology I and II College and Career Readiness Standards*

Unit 1	ZOO.1 Students will develop a model of evolutionary change over time.
Unit 2	ZOO.2 Students will understand the structure and function of phylum **Porifera** and phylum Cnidaria and how each adapts to their environments.
Unit 3	ZOO.2 Students will understand the structure and function of phylum Porifera and phylum **Cnidaria** and how each adapts to their environments.
Unit 4	ZOO.4 Students will describe the evolution of structure and function of phylum Platyhelminthes, phylum Nematoda, and phylum Annelida.
Unit 5	ZOO.3 Students will understand the structure and function of phylum Mollusca, and how they adapt to their environments.
Unit 6	ZOO.5 Students will understand the basic structure and function of phylum Arthropoda, and how they demonstrate the characteristics of living things.
Unit 7	ZOO.6 Students will understand the structure and function of phylum Echinodermata, and how they demonstrate the characteristics of living things.
Unit 8	ZOO.7 Students will understand the structure and function of **phylum Chordata, classes Chondrichthyes** and Osteichthyes, and how they demonstrate the characteristics of living things.

Table 1 (continued)

Unit 9	ZOO.7 Students will understand the structure and function of phylum Chordata, classes Chondrichthyes and **Osteichthyes,** and how they demonstrate the characteristics of living things.
Unit 10	ZOO.8 Students will understand the structure and function of phylum Chordata, classes **Amphibia** and Reptilia, and how they demonstrate the characteristics of living things.
Unit 11	ZOO.8 Students will understand the structure and function of phylum Chordata, classes Amphibia and **Reptilia,** and how they demonstrate the characteristics of living things.
Unit 12	ZOO.9 Students will understand the structure and function of phylum Chordata, class Aves, and how they demonstrate the characteristics of living things.
Unit 13	ZOO.10 Students will understand the structure and function of phylum Chordata, class Mammalia, and how they demonstrate the characteristics of living things.

Table 1. Zoology I standards are not shaded and Zoology II standards are greyed. Mississippi College and Career Readiness Science Standards for Zoology I and II (Mississippi Department of Education, 2017).

Self-efficacy questionnaires were administered as pre-test at the beginning of the course as baseline data. A final administration of the same questionnaire was completed by students at the conclusion of their final unit with instantaneous feedback of CRS as illustrated in Tables 2 and 3 with Experimental Timeline.

Only one class of students received instantaneous feedback, the treatment, with their CRS during an instructional unit with formative and summative assessments. After two consecutive units, the treatment of instantaneous feedback with CRS was switched to the other class, meaning the first class did not receive instantaneous feedback with CRS. The instructional unit that began during the fourth week of instruction switched the treatment of instantaneous feedback with CRS again to the first class with formative and summative assessments. This quasi-experimental design ensured ability groups and

intelligence levels did not factor as an influence on the outcome of measured assessment scores. Data was collected through a total of 12 units of instruction, totaling 28 formative assessment scores and twelve summative assessment scores from each class. Tables 2 and 3 illustrated the experimental timeline.

Table 2 *First Nine Week Instructional Timeline*

Time	**Week 1 Unit 1 Intro**	**Week 2-3 Unit 2 Porifera**	**Week 3-4 Unit 3 Cnidaria**	**Week 5-6 Unit 4 Helminth**	**Week 7-8 Unit 5 Mollusk**	**Week 8-9 Unit 6 Arthropod**	**Week 9 Unit 7 Echino-**
Class A Block 3	FA = 2 SA = 1 **SE**	FA = 2 SA = 1 **X**	FA = 3 SA = 1 **X**	FA = 3 SA = 1	FA = 3 SA = 1	FA = 3 SA = 0 **X**	FA = 1 SA = 0 **X**
Class B Block 4	FA = 2 SA = 1 **SE**	FA = 2 SA = 1	FA = 3 SA = 1	FA = 3 SA = 1 **X**	FA = 3 SA = 1 **X**	FA = 3 SA = 0	FA = 1 SA = 0

Table 2. Experimental Timeline. FA = Formative Assessment, SA = Summative Assessment, X = treatment, instantaneous feedback with CRS, SE = Self-Efficacy Questionnaire

Table 3 *Second Nine Week Instructional Timeline*

Time	**Week 11-12 Unit 8 Chord/shark**	**Week 12-13 Unit 9 Bony Fish**	**Week 13-14 Unit 10 Amphibia**	**Week 15 Unit 11 Reptile**	**Week 16-17 Unit 12 Aves**	**Week 18 Unit 13 Mammals**
Class A Block 3	FA = 4 SA = 1	FA = 2 SA = 1	FA = 2 SA = 1 **X**	FA = 2 SA = 1 **X**	FA = 2 SA = 1	FA = 2 SA = 0 **SE**
Class B Block 4	FA = 4 SA = 1 **X**	FA = 2 SA = 1 **X**	FA = 2 SA = 1	FA = 2 SA = 1	FA = 2 SA = 1 **X**	FA = 2 SA = 0 **X/SE**

Table 3. Experimental Timeline. FA = Formative Assessment, SA = Summative Assessment, X = treatment, instantaneous feedback with CRS, SE = Self-Efficacy Questionnaire

Summary

This chapter reviewed the methodology incorporated in order the answer the current research questions posed by the researcher follows a chronological order. The quantitative, quasi-experimental design began with a description of the school district, instructor, and student participants. Descriptions of the instruments included formative assessments, summative assessments, and self-efficacy questionnaire. Approval with school district personnel and Research Collaboration was obtained (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). Recruitment and commitment with an independent research assistance was obtained. A summary of the research timeline concluded this chapter.

CHAPTER IV– RESULTS

The purpose of this study was to study the effect of instantaneous feedback with classroom response systems (CRS) and results of self-efficacy questionnaires with secondary science students. Formative and summative test scores were collected with and without instantaneous feedback features throughout the fall semester between two zoology classes in a secondary science setting. Pretest and posttest survey items measuring self-efficacy completed by secondary science students were also collected. This chapter presents results of data analysis with raw scores from formative assessments, summative assessments, and self-efficacy questionnaire results. Formative and summative assessments were teacher generated utilizing MS College and Career Readiness Science Standards for Zoology I and II adopted in 2017. Self-efficacy questionnaire from Research Collaboration with permission was administered as pretest and posttest format (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). Quantitative data from formative assessments, summative assessments, and self-efficacy questionnaire results was entered into Excel software and SPSS software (Grad Pack 25.0 STANDARD, January 2019) for descriptive statistics, independent sample *t*-test, paired measures *t*-test, and Pearson Correlation.

A total of 43 students completed the Fall 2018 Semester of Zoology I and II at a rural high school in South Mississippi conducted during the afternoon block sessions. Nineteen students returned signed IRB participation forms from block 3 and 20 students returned signed IRB participation forms from block 4; therefore, the participation total for this study is 39 (N=39). The same instructor taught both classes during the Fall 2018

Semester incorporating the same formative assessments, summative assessments, and self-efficacy questionnaire.

Table 4 *Descriptive Statistics of Participants*

Variable		Frequency	Percent
Gender			
Male (M)		17	43.6%
Female (F)		22	56.4%
Grade Level			
12th Grade		**7**	**17.9%**
	M / F	3 / 4	7.7% / 10.3%
11th Grade		**14**	**35.9%**
	M / F	8 / 6	20.5% / 15.4%
10th Grade		**18**	**46.2%**
	M / F	6 / 12	15.4% / 30.8%
Ethnicity			
Caucasian		36	92.3%
African-American		1	2.6%
Hispanic		2	5.1%

Table 4. The frequencies and percentages of participants by gender, secondary school grade level, and ethnicity are presented.

Findings

Formative and summative raw scores were collected during Units 2-13, from Zoology I and II. Each unit comprised the adopted MS Career and College Readiness Science Standards for Zoology I and II in which the study was conducted. Tables 1-2 (pp 42-43) outlines the topics covered in each unit. The raw scores from the formative and summative assessments were totaled and compressed into a single percentage score for each unit to be incorporated with SPSS software. Figures 2 and 3 demonstrate example students in opposite classes demonstrating opposing trends with CRS feedback and without CRS feedback.

Figure 2. Sample Block Three Student Unit Percentages

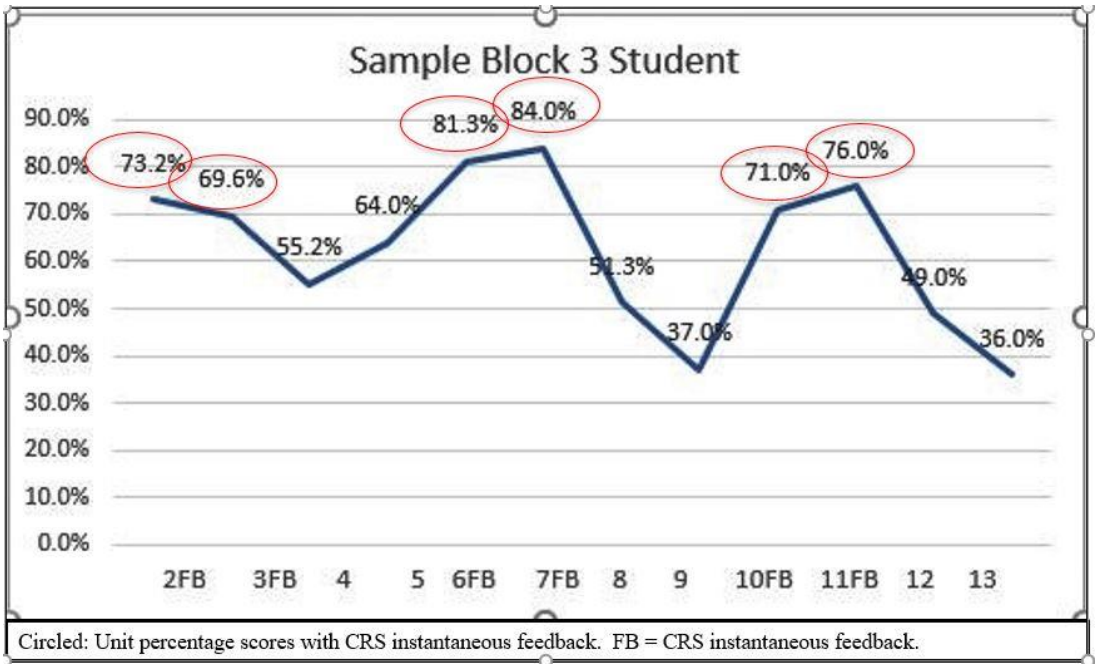
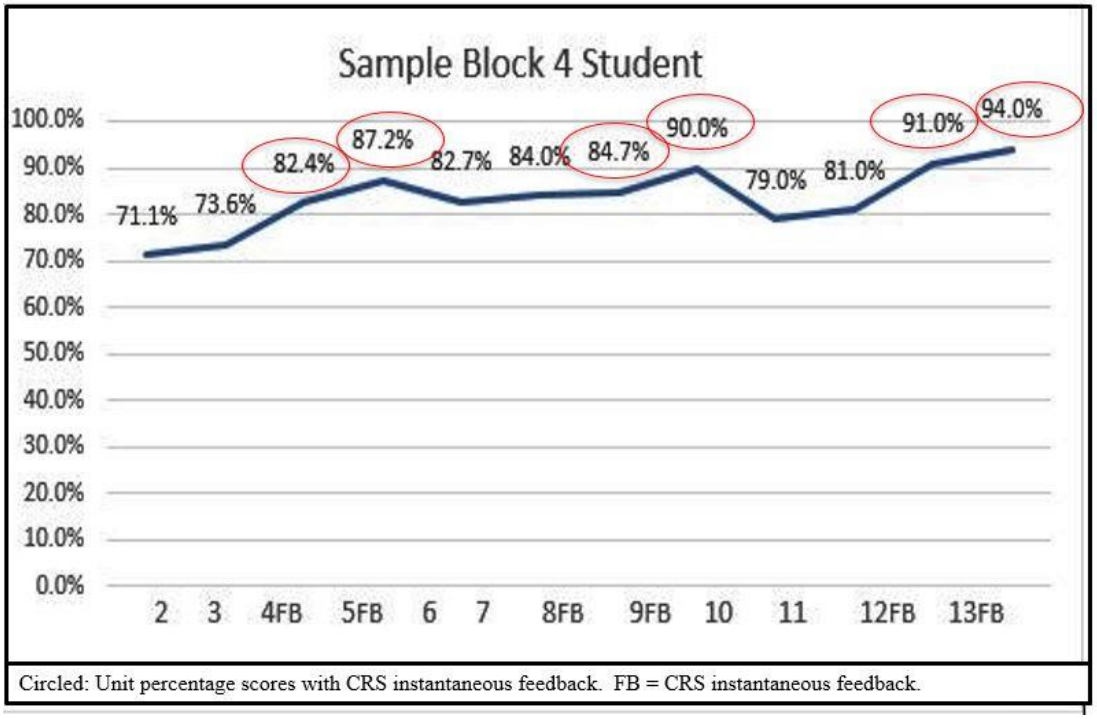


Figure 3. Sample Block Four Student Unit Percentages



Figures 4 and 5 are bar graphs demonstrate Units 2-13 scores with CRS feedback and without CRS feedback.

Figure 4. Unit percentage scores with CRS feedback

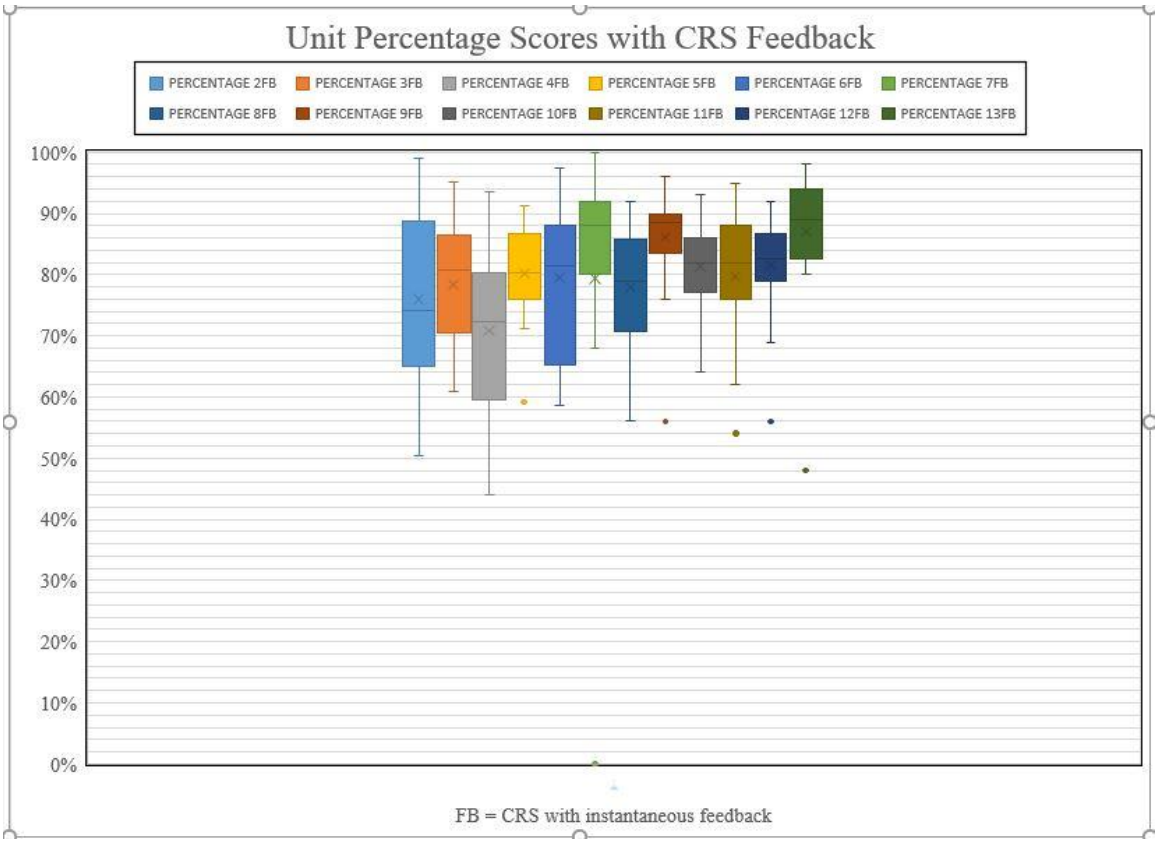
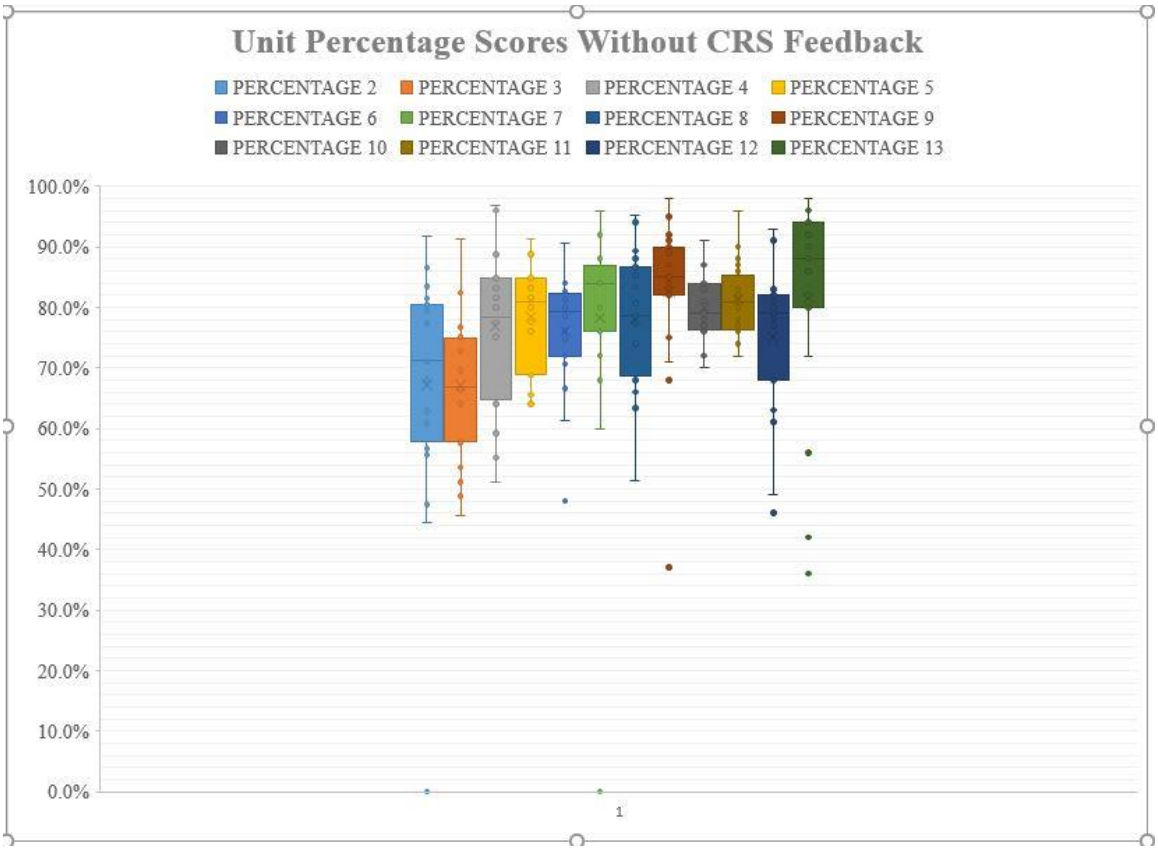


Figure 5. Unit percentage scores without CRS feedback



Figures 6 and 7 demonstrated Zoology I and II sections demonstrating the overall differences between CRS feedback scores and CRS scores without feedback.

Figure 6. First Nine Week Class Percentage Scores with and without CRS feedback

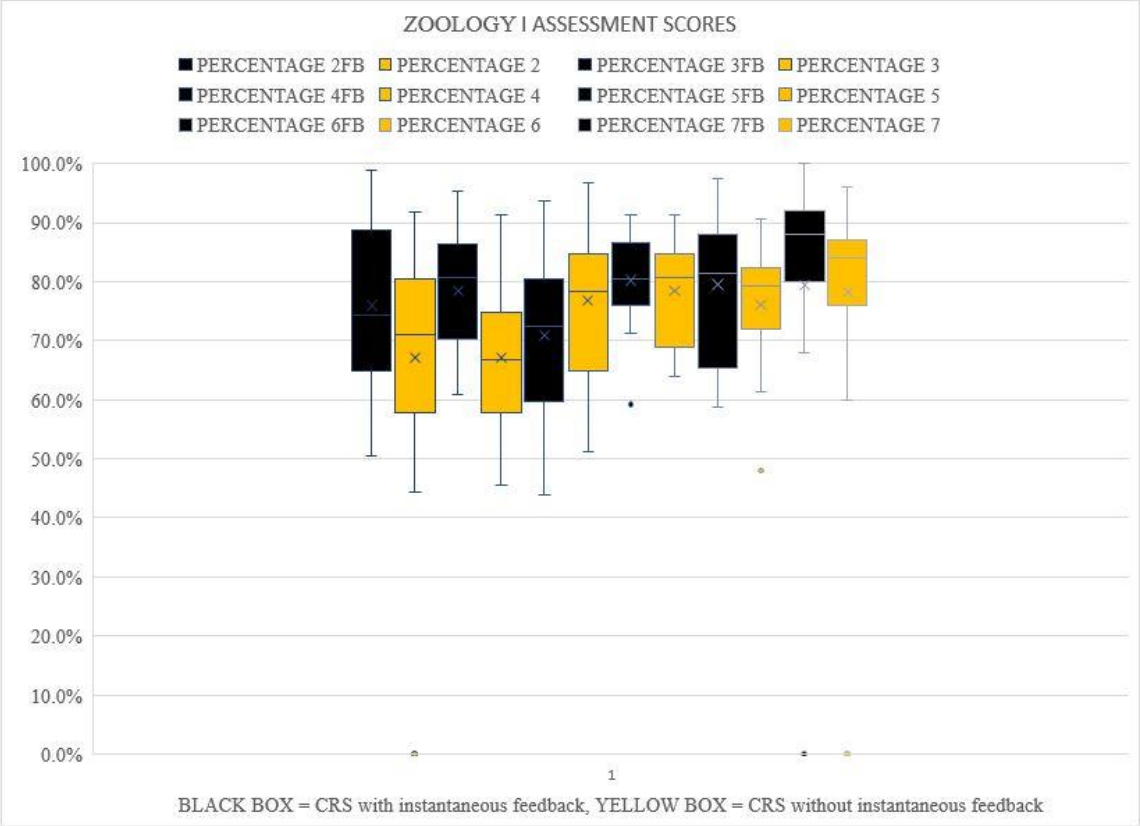


Figure 7. Second Nine Week Class Percentage Scores with and without CRS feedback

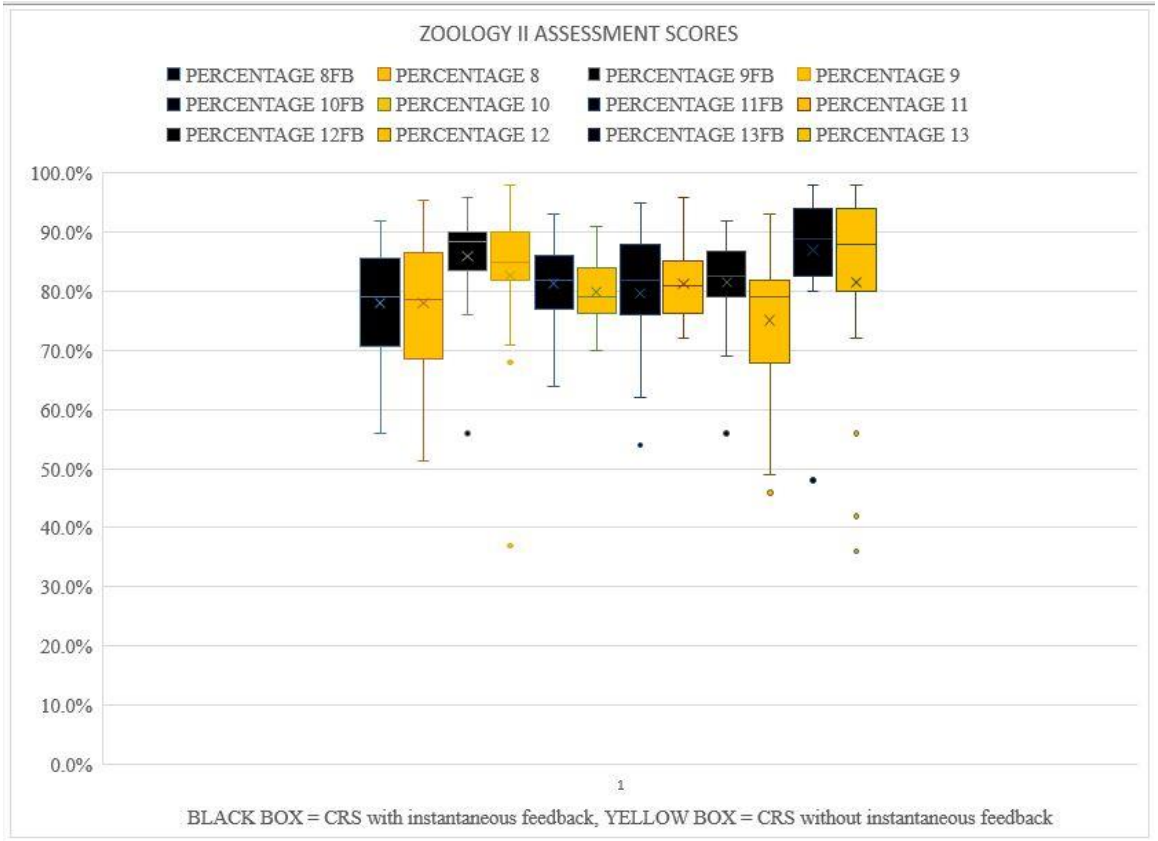


Table 5 demonstrated the unit means for each unit reflecting an increase or decrease in scores among the two groups in Zoology I and II.

Table 5 *Instructional Unit Mean Scores*

INSTRUCTIONAL UNIT	WITHOUT CRS INSTANTANEOUS FEEDBACK	WITH CRS INSTANTANEOUS FEEDBACK	DIFFERENCE
UNIT 2 (Porifera)	21.73	24.56	2.83
UNIT 3 (Cnidaria)	20.95	24.52	3.57
UNIT 4 (Helminths)	24.03	22.16	-1.87
UNIT 5 (Mollusks)	24.53	25.06	0.53
UNIT 6 (Arthropods)	19.02	19.88	0.86
UNIT 7 (Echinoderms)	19.55	19.84	0.29

Table 5 (continued)

UNIT 8 (Chordate/Shark)	23.42	23.39	0.03
UNIT 9 (Osteichthyes)	27.56	28.68	1.12
UNIT 10 (Amphibians)	26.63	27.09	0.46
UNIT 11 (Reptiles)	27.08	26.58	-0.50
UNIT 12 (Aves)	25.05	27.77	2.72
UNIT 13 (Mammals)	20.39	21.75	2.02

Table 5. Descriptive statistics for each assessment for Zoology I and II displaying mean scores for all assessments within individual units.

Table 6 illustrated the means between the pretest and posttest Research Collaboration Self-Efficacy scores.

Table 6 *Descriptive Statistics of Self-Efficacy Questionnaire*

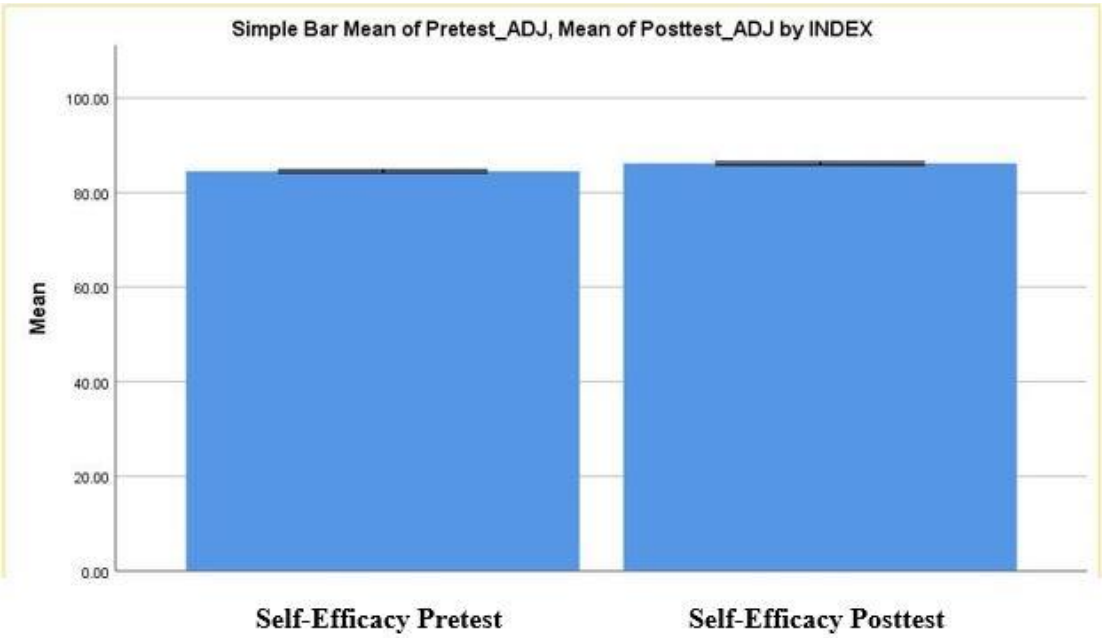
SELF-EFFICACY QUESTIONNAIRE	***N***	**MEAN**	***SD***
Pretest Self-Efficacy Questionnaire	39	84.50	8.87
Posttest Self-Efficacy Questionnaire	39	86.16	7.95

Table 6. Descriptive statistics for each administration of Research Collaboration's Self-Efficacy Questionnaire administered as pretest in August 2018 and posttest in December 2018.

Research Collaboration's self-efficacy questionnaire was completed by each participant within the first week of instruction, August 2018, as a pretest measurement and then again during the second week of December 2018, for posttest measurement. Self-Efficacy questionnaire is composed of thirteen ranking questions that is designed to measure the student's beliefs in his ability and ability can grow with effort. Eight separate scoring items measure each student's belief in his individual ability and five separate scoring items measure how ability can grow with effort. Each score is displayed

on a 100-point scale (Gaumer Erickson, Soukup, Noonan, & McGurn, 2018). Figure 8 demonstrated students' pretest mean and posttest mean from the questionnaire.

Figure 8. Self-Efficacy Pretest and Posttest Comparison with Error Bars



Descriptive analyses with SPSS software demonstrated differences among the means between two conditions. With the exception of Unit 4, mean scores were most often higher when CRS feedback feature was incorporated with students. Seventy-one percent of scores were higher when CRS feedback was enabled with student assessments. Overall, there was a 3.52% gain in mean scores. Self-Efficacy questionnaire results percent increase were 1.96% from August to December 2018, with the integration of CRS feedback within Zoology I and II courses.

Results of Research Question One and Hypothesis

Research Question One stated: Does instantaneous feedback via classroom response systems increase student concept knowledge with formative/summative assessments in a secondary science classroom?

Research Hypothesis One: Students who receive instantaneous feedback via classroom response systems during formative/summative assessments will demonstrate a statistically significant increase in knowledge scores with formative/summative assessments.

A SPSS independent *t*-test was conducted to demonstrate the difference between percentage scores with CRS feedback (M = 79.27, SD = 13.56) and percentage scores without CRS feedback (M = 76.87, SD = 13.99). The assumption of homogeneity of variance was met between these two groups $F(1,466) = .190$, $p = .663$. The results of the independent *t*-test reported a conclusion of a statistically significant difference, $t(466) = 2.24$, $p = .025$, $d = 0.21$. Therefore, student percentage unit scores with CRS feedback were higher than student percentage unit scores without CRS feedback.

Results of Research Question Two and Hypothesis

Research Question Two stated: Does instantaneous feedback via classroom response systems increase student self-efficacy in a secondary science classroom?

Research Hypothesis Two: Students who receive instantaneous feedback via classroom response systems will demonstrate a statistically significant increase in perceived self-efficacy as revealed by Research Collaboration's Self-Efficacy Questionnaire results.

Paired samples SPSS *t*-test was conducted to demonstrate the difference between pretest and posttest student scores with Research Collaboration's Self-Efficacy results. Due to a low number of participants (N=39), skew level of -1.33 and kurtosis level of 1.54 was investigated to test for normality. Results calculated by SPSS software paired samples *t*-test results were $t(38) = -5.40$, $p < .001$. The students' posttest mean scores of

Research Collaboration's Self-Efficacy questionnaire was statistically higher from pretest mean scores, indicating an increase of self-efficacy at the conclusion of Zoology I and II Fall 2018 semester (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016).

Results of Research Question Three and Hypothesis

Research Question Three stated: Does instantaneous feedback via classroom response systems influence a correlation between self-efficacy and content knowledge in a secondary science classroom?

Research Hypothesis Three: Students who receive instantaneous feedback via classroom response systems will demonstrate a correlation between self-efficacy and knowledge as revealed by formative/summative assessment scores and Self-Efficacy Questionnaire results.

A Pearson Correlation examined the relationship between the percentage score averages of student assessments and posttest Research Collaboration's Self-Efficacy scores (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). All of the calculated unit percentages for students were averaged to obtain an overall average for Zoology I and II Fall 2018 Semester. The mean for assessments was 78.35 (SD = 8.73). The mean for the Self-Efficacy posttest was 86.16 (SD = 7.96). The relationship described by the Pearson Correlation analysis was negative, weak in strength, and not statistically significant (r (37) = .28, p = .09).

Summary

The research questions were answered incorporating descriptive statistics, frequencies, independent sample *t*-test, paired sample *t*-test, and Pearson Correlation. This study analyzed formative assessment unit scores, summative assessment unit scores,

and Research Collaboration's Self-Efficacy Questionnaire scores (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). Formative and summative unit scores with CRS instantaneous feedback were alternated in a quasi-experimental design among two afternoon classes of Zoology I and II. A statistically significant difference among CRS scores with feedback was compared to with CRS scores without feedback. Also, a statistically significant difference was found between pretest self-efficacy scores and posttest self-efficacy scores. There was no significant correlation between CRS scores and self-efficacy questionnaire posttest results. Hypothesis two and three was supported. Hypothesis three was not supported.

CHAPTER V– DISCUSSION

Advancements in technology have been ingrained into every facet of our lives, including the academia sector. While computers, laptops, and tablets offer great diversity, their expense and maintenance are often too extensive for rural school districts to provide individual accessibility. Classroom response systems (CRS) offer an economical, versatile, and effective individual technological advancement within many scholastic levels. Benefits of CRS, including engagement, motivation, grades, and retention, have been demonstrated throughout many longitudinal studies.

Since their conception in the late 1960s, the integration of CRS within the classroom setting has been measured as high as 30% of classrooms within the United States in 2012 (Mahon, 2012, p. 2-3). The level of integration, frequency of use, and instantaneous feedback features are several variables that may be measured regarding CRS within the educational setting. Middle school students demonstrated higher achievement and enjoyment with the implementation of CRS (Cohn & Fraser, 2016). Many post-secondary studies have reported increased student attendance, engagement, motivation, peer instruction, subject matter retention, grades, and even confidentiality (Mahon, 2012). Several of these post-secondary educational settings have overlapped these studies with attitude questionnaires that measured increased amenity, convenience, and enjoyment with student use (Mahon, 2012). However, there is a lack of secondary school studies regarding the specific feature of instantaneous feedback with CRS.

Summary of the Study

This study focused on the measured concept gains of student knowledge with the integration of instantaneous feedback with CRS in a secondary science classroom.

Research Collaboration's Self-Efficacy questionnaire also measured any increased individual student self-efficacy at the conclusion of this study (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). The study included two afternoon Zoology I and II classes during the Fall 2018 semester in a south Mississippi rural school. While all students utilized CRS throughout the entire semester, the treatment of instantaneous feedback was applied consecutively to one class for two units, before alternating to the other class for the following two units, and alternating again until the conclusion of the semester. Teacher generated formative and summative assessments were measured throughout all twelve units.

Several statistical analyses were conducted at the conclusion of this study. A descriptive analysis of assessment means between assessments from CRS instantaneous feedback and the same assessments without CRS instantaneous feedback resulted in a positive gain in assessment scores with CRS instantaneous feedback. An independent *t*-test demonstrated a significantly higher difference in unit percentages with students that received instantaneous feedback with CRS. The *t*-test was selected for analysis due to its reliance with violations of normality assumption since data was continuous, unimodal, and reasonably symmetric. A paired sample *t*-test illustrated a statistically significance between Research Collaboration's Self-Efficacy questionnaire student pretest scores and posttest scores. Finally, a Pearson's Correlation was utilized to measure any correlation between Research Collaboration's Self-Efficacy questionnaire student posttest scores and CRS scores with feedback (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016).

Description of Study Variables

The variables in this study consisted of teacher generated formative and summative assessments throughout twelve units in Zoology I and II (Appendix L and P). These assessments were correlated with the Mississippi College and Career Science Standards adopted by the Mississippi Department of Education (Mississippi Department of Education, 2017). Each formative assessment is composed of 25 multiple choice questions ranging from basic knowledge to evaluation skill levels. Each summative assessment is composed of 47-50 multiple choice questions ranging from basic knowledge to evaluation skill levels. All students utilized CRS remotes with all assessments; however, the treatment of instantaneous feedback was only applied to one class and alternated every two units.

Research Collaboration's Self-Efficacy questionnaire was also a variable in this study (Appendix H). Each self-efficacy questionnaire was composed of thirteen ranking questions designed to measure the student's beliefs in his ability and ability can grow with effort. Eight separate scoring items measured each student's belief in his individual ability and five separate scoring items measured how ability can grow with effort. Each score displayed on a 100-point scale (Gaumer Erickson, Soukup, Noonan, & McGurn, 2018). This questionnaire was administered at the beginning of the study as a pretest measurement, August 2018, and again as a posttest measurement, December 2018.

Analysis of Research Questions and Hypotheses

Incorporating technology such as CRS has demonstrated an increase in learning benefits (Middleditch & Mondrot, 2015). Deal (2007) clarified CRS as the most successful form of beneficial technology for a classroom setting. Additionally, a post-

secondary study including a physiology class resulted in not only positive student evaluations, but also increased student academic achievement (Gauci et al., 2009). Sun (2012) expressed the value of an immediate feedback loop as a necessary component for maximum student engagement, contributing to increased student self-efficacy.

Descriptive analyses with SPSS software demonstrated differences among the means between two conditions. With the exception of one unit, mean scores were most often higher when CRS feedback feature was incorporated with students. Overall, there was a positive gain in mean scores with the implementation of CRS instantaneous feedback. Self-Efficacy questionnaire results measured a positive change with the integration of CRS feedback within a secondary science course.

There may be several reasons why Unit 4 scores did not demonstrate higher student means with CRS instantaneous feedback. First, this unit included individual student presentations, resulting in all of the unit formative assessments being completed overnight, as homework. This provided an opportunity for students to share answers, when other unit formative assessments were completed during class sessions with direct teacher supervision. Also, the quality of individual student presentations may have influenced overall measured student achievement. Several students weren't successful with their requirements of their individual projects, perhaps lowering the quality of concepts presented during this unit. Finally, some students prioritized their individual presentations excessively, resulting in little effort preparing for the summative assessment at the conclusion of the unit. The combined summative mean score for this unit is the second lowest of all the summative assessment mean scores.

Research Question One

Research Question One stated: Does instantaneous feedback via classroom response systems increase student concept knowledge with formative/summative assessments in a secondary science classroom?

Studies have compared classes with and without clickers utilized during summative assessments and measured higher assessment scores with CRS integration (Bruff, 2018). Specifically, instantaneous feedback in a distance learning environment demonstrated positive student academic achievement (Berry, 2009). Other classroom activities, such as lectures and games with the integration of CRS have also measured increased student achievement (Gauci et al., 2009; Rouse, 2013).

Research Hypothesis One

Research Hypothesis One stated: Students who receive instantaneous feedback via classroom response systems during formative/summative assessments will demonstrate a statistically significant increase in knowledge scores with formative/summative assessments.

The results of this study supported this research hypothesis. The raw scores for each assessment within individual units were compressed into a single percentage score for the unit. Twelve units were compared with and without the treatment of CRS instantaneous feedback. This comparison demonstrated statistically significant higher scores of students with CRS instantaneous feedback. These finding contribute to the growing body of evidence that not only CRS integration increased student achievement, but also specifically, the incorporation of CRS instantaneous feedback (Berry, 2009).

Additionally, efforts with the experimental design addressed the common "Hawthorne Effect". All students used CRS with all assessments, clarifying the treatment between scores was isolated to the feature of instantaneous feedback. The novelty of technology use was not responsible or influencing the outcome of this educational study, skewing data due to the treatment of student use with CRS, and this special treatment causes the measured improvements rather than the feature of instantaneous feedback (Caldwell, 2017).

Research Question Two

Research Question Two stated: Does instantaneous feedback via classroom response systems increase student self-efficacy in a secondary science classroom?

Students with successful academic performance experienced increased confidence, which encouraged the student to take greater responsibility for successful academic tasks. Past literature research has illuminated students with a higher aptitude that had better academic performance, and more positive evaluations reported higher self-efficacy (Komarraju & Nadler, 2013).

Reported fluctuations in self-efficacy have mirrored student performance feedback. Unfortunately, they parallel, low achieving students report less confidence and high performing students report higher self-confidence. High performing students also report a greater value for their learning (Komarraju & Nadler, 2013). This study provided ample opportunity for student feedback with the CRS and influenced their own perceived self-efficacy.

Research Hypothesis Two

Research Hypothesis Two stated: Students who receive instantaneous feedback via classroom response systems will demonstrate a statistically significant increase in perceived self-efficacy as revealed by Research Collaboration's Self-Efficacy Questionnaire results.

The results of this study supported this hypothesis. Comparisons among student scores demonstrated a statistically significant difference between pretest and posttest student scores with Research Collaboration's Self-Efficacy results (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). Students completed thirty-eight different assessments during the Zoology I and II course with CRS, which provided ample opportunity for timely student performance feedback, indicated an increase of self-efficacy at the conclusion of the Fall 2018 semester.

Research Question Three

Research Question Three stated: Does instantaneous feedback via classroom response systems influence a correlation between self-efficacy and content knowledge in a secondary science classroom?

Review of literature demonstrated effort regulation a strong variable in regards to increasing self-efficacy; however, the study involved post-secondary students, rather than secondary level students (Komarraju and Nadler, 2013). A study of students within a secondary educational setting determined academic interest and intrinsic vs. external need for cognition were the largest two variables to influence academic self-efficacy (van Rooij et al., 2017). An assumption of academic interest was a logical conclusion since

Zoology I and II is an elective course within this school district and not mandatory to obtain a high school diploma.

Research Hypothesis Three

Research Hypothesis Three stated: Students who receive instantaneous feedback via classroom response systems will demonstrate a correlation between significant increase in perceived self-efficacy and knowledge as revealed by formative/summative assessment scores and Self-Efficacy Questionnaire results.

The results of this study did not support this hypothesis. A Pearson Correlation examined the relationship between the percentage score averages of student assessments and posttest Research Collaboration's Self-Efficacy scores (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). The relationship described by the Pearson Correlation analysis was negative, weak in strength, and not statistically significant.

Implications for Policy and Practice

The results of this study could impact secondary educational settings by its positive academic benefits with the integration of CRS within a secondary science course. These results provided evidence that the novelty of utilizing technology was not an influencing variable for increased academic achievement, but the feature of instantaneous feedback that is available with some CRS brands. This study also demonstrated an increase of student self-efficacy with the integration of CRS technology with instantaneous feedback. Teachers are constantly seeking improved methods to increase student success in the classroom, and CRS integration provides a viable, competent solution, not only in the realm of individual student gains, but also logistically

within a classroom setting. The flexibility, economic affordability, and independence provide additional rationales for the incorporation within an educational setting.

Review of literature has noted many instructional methods including peer instruction, assessing-for-learning, deliberate practice, ConcepTests, Just-in-time teaching, and Interactive Lecture Demonstrations that may successfully incorporate CRS demonstrating the flexibility of this technology (Calhoun et al., 2018; Mahon, 2012, p. 4). A CRS set, with an average cost of approximately $2000, can provide individualized experiences with a large class size (Learning Services, 2018) and is independent from internet bandwidth. Successful CRS integration is only limited by an instructor's determination and imagination.

Teacher candidates typically have a technology integration course within their college programs. The goal of this course includes exposure and preparation of new teachers for common technology that is often incorporated within an educational setting. The results of this study demonstrated the value of incorporation of instantaneous feedback with student success. The popularity of CRS is easily documented since 2012, an estimated 30% of schools within the United States have incorporated CRS within classrooms manufactured by 18 different companies (Mahon, 2012). Instantaneous feedback feature may influence the particular brand teachers and instructional coaches choose for their students.

Improved instructional methods are a consistent goal for many teachers, but the implementation of instantaneous feedback affects individual students and their academic success. Results of this study demonstrated an increase in student content knowledge with higher mean scores with formative and summative assessments. As students gain

content knowledge, their self-efficacy increased. A student's belief in their own ability may affect more than just increased grades in a secondary science course. Higher personal goals of students often exhibit the potential for student success, even beyond their high school experience, into productive work careers.

Limitations

The participants of this study included Zoology I and II students within a south Mississippi rural school. Not only the school's student population, but also Zoology I and II participants are not reflective of the diversity within the general public population. Also, the sample size for this study may be an additional limitation. A quasi-experimental design was developed to assist with this possible limitation. Due to the lack of diversity and large sample size, the results of this study cannot be generalized beyond a similar rural secondary school setting. The type and number of participants is only one limitation.

An additional limitation with this study is the type of content that was presented during Zoology I and II. These topics were limited to some taxonomy, animal features, and ecological relationships found in the Mississippi College and Career Readiness Science Standards (Mississippi Department of Education, 2017). Zoology I and II is a science elective option for our student after successful completion of biology. Conversations with past and present students have illuminated their placement in this elective course occasionally as the result of filling a science requirement for graduation, rather than genuine student interest. These students often have interests in other subjects, rather than Zoology I and II, limiting their potential for academic success. While type of

content material may present a possible limitation, the instructor could also be a potential limitation.

The instructor was also the researcher. The variability of multiple instructional methods, types of assessments, and pacing was reduced due to the same instructor for both afternoon classes of Zoology I and II. However, participant forms were explained, collected, and stored by a certified colleague to reduce bias during the Fall 2018 semester. The instructor has completed many biological college courses throughout her teaching career in an effort to earn advanced degrees in additional to twenty-five years of experience with Zoology content in a high school setting.

Student effort and honesty presented another possible limitation. Students may not have been honest in their Research Collaboration Self-Efficacy questionnaires (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). Some students may not have carefully considered the questionnaire questions since it had no academic scoring for their grade in the Zoology I or II course. Finally, students had an opportunity to copy other student answers on some assessments, specifically Unit 4. Teacher supervision was diligent; however, Unit 4 formative assessments were all assigned as homework due to the pacing of disease presentations during the same unit.

Recommendations for Future Research

This study illuminated the positive effects of instantaneous feedback feature with CRS in a secondary science course by measuring assessment scores and self-efficacy questionnaire results with thirty-nine students. Repeating this study with not only secondary students, but also middle school and post-secondary students, will add validity to these findings. Participants in future longitudinal studies should also include other

areas around the country, rather than just a rural south Mississippi secondary school, and should also reflect a general population diversity. Finally, different subjects other than Zoology I and II may also support the positive effects of instantaneous feedback with CRS in the classroom.

Instrumentation may also be varied to provided more support for student content knowledge and gains with self-efficacy. Possible short, daily quizzes and end of course comprehensive assessments could be utilized as opportunities to measure student instantaneous feedback academic gains. Research Collaboration's Self-Efficacy questionnaire addressed individual beliefs concerning their individual ability, and ability can grow with effort (Glynn & Koballa, 2006; Gaumer Erickson, et al., 2016). This questionnaire did not specifically address students relating the integration of instantaneous feedback with those abilities and potential growth efforts. Development of a questionnaire addressing instantaneous feedback would isolate any measurement of growth to this experimental variable.

Summary

The purpose of this study was to illuminate the benefits of instantaneous feedback and student self-efficacy with incorporation of CRS in a secondary science course. A statistically significant different was demonstrated between formative and summative assessments with instantaneous feedback of CRS among students in a Zoology I and II secondary science course. Gains in student self-efficacy was also measured; however, there is no positive correlation among student high academic scores and self-efficacy scores. Limitations and future research recommendations illuminated quasi-experimental variables in greater detail.

APPENDIX A – IRB Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 18082701
PROJECT TITLE: Classroom Response Systems: Does Instantaneous Feedback Affect Students' Knowledge and Self-Efficacy in a Secondary Science Course?
PROJECT TYPE: Doctoral Dissertation
RESEARCHER(S): Shani Bourn
COLLEGE/DIVISION: College of Arts and Sciences
DEPARTMENT: Center for Science and Math Education
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Exempt Review Approval
PERIOD OF APPROVAL: 09/07/2018 to 09/07/2019

Edward L. Goshorn, Ph.D.
Institutional Review Board

APPENDIX B Superintendent Approval Letter

Hancock County School District
Alan Dedeaux, Superintendent of Education

17304 Highway 603 • Kiln, Mississippi 39556
228-255-0376 Phone 228-255-0378 Fax
www.hancockschools.net

July 26, 2018

University of Southern Mississippi
Institutional Review Board

To Whom It May Concern:

This letter serves as my approval to allow Shani Bourn to measure student knowledge gains with the incorporation of instantaneous feedback with a classroom response system and measurement of student self-efficacy using a published questionnaire on zoology students in her dissertation research during the 2018 Fall Semester at Hancock High.

Respectfully,

Alan Dedeaux
Superintendent

AD:cb

APPENDIX C Principal Approval Letter

Hancock High Science Department

Hancock High School
7084 Stennis Drive
Kiln, MS 39556

Phone 467-2251
Fax 467-2689

July 25, 2018

Mrs. Tara Ladner,

I have taught at Hancock High since 1992, teaching a variety of courses including biology, zoology, environmental science, marine and aquatic science, AP biology and DC biology. I am also a doctoral student with The University of Southern Mississippi majoring in Science Education, emphasis in Coastal Sciences.

I am seeking permission to use my Fall Semester, 2018, zoology students in my dissertation research. USM's Institutional Review Board approval, parent/guardian approval, and student assent will be obtained prior to collecting data. Also, I have gained the support and assistance of a fellow teacher to ensure measures to protect student identity and researcher bias.

The study will measure student knowledge gains with the incorporation of instantaneous feedback with my classroom response system and measurement of student self-efficacy with instantaneous feedback using a published questionnaire.

Attached you will find my experimental timeline, self-efficacy questionnaire, sample formative assessment, and sample summative assessment that are teacher generated that will be utilized in my study.

Thank you for your time and consideration with this matter.

Shani Bourn

Shani Bourn, M.S.Ed., NBCT
HHS Science Honor Society Sponsor
HHS Science Club Sponsor
HHS Science Department Chair

8/9/18

APPENDIX D Research Collaboration Approval Email

Gmail by Google

Bourn, Shani <sbourn@hancockschools.net>

Instrument Usage Approval

Noonan, Pattie <pnoonan@ku.edu> Thu, Jul 26, 2018 at 10:37 AM
To: "Bourn, Shani" <sbourn@hancockschools.net>, Research Collaboration <researchcollab@ku.edu>, "Gaumer Erickson, Amy" <agaumer@ku.edu>

Hi Shani,

Yes, you may use the Self-Efficacy Questionnaire with an appropriate citation. You are also welcome to add or modify items. In our continued research on self-efficacy, a limitation we've found to the questionnaire is that it is not content or context specific (i.e., students can have high self-efficacy in some areas like sports, music, algebra, but low self-efficacy in other areas such as reading). Modifying to fit the specific aspects of your project will likely improve the questionnaire. Please note that we have not yet developed any peer-reviewed publications on the survey, it is not normed, and there are no reverse-scored items. We use it primarily as a student reflection tool and teacher planning tool. If you launch the survey through http://researchcollaborationsurveys.org/ it will automatically create a summary report for each student and provide you with composite data (in a summary report and excel download).

I have attached the technical information on the scale.

Thank you,

Pattie

Patricia Noonan, Ph.D.

Associate Research Professor – University of Kansas

Consultant – Noonan Gaumer Erickson, LLC

www.researchcollaboration.org

pnoonan@ku.edu

785.864.0593

From: Bourn, Shani <sbourn@hancockschools.net>
Sent: Wednesday, July 25, 2018 4:40 PM
To: Research Collaboration <researchcollab@ku.edu>; Noonan, Pattie <pnoonan@ku.edu>; Gaumer Erickson, Amy <agaumer@ku.edu>
Subject: Instrument Usage Approval

[Quoted text hidden]

Self-EfficacyQuestionnaireInfo_ June 2018.pdf
238K

APPENDIX E Research Assistant Proposal Script

You have a special opportunity this semester. Your teacher, Ms. Bourn, is finishing her doctorate program at USM, which includes a study, almost like a science fair project, but with much greater detail. Her study includes you and your Qwizdom response remotes.

READ #1 and #2 from MINOR ASSENT FORM

Why am I explaining this to you? Because Ms. Bourn will not know who has agreed to participate in any of her classes. This is ensure that researcher bias does not enter the study. (you will need to explain what bias is to them)

She can answer questions about the study, but she will NOT know who has agreed to participate until after December 20. That's when she will start analyzing the data that has been collected. So, you will stop by my room to hand in your signed forms, BOTH forms MUST be signed or you cannot participate.

WHERE IS MY ROOM? (Be sure to give directions in addition to your room number).

WHEN WILL YOU TURN IN SIGNED FORMS? AT THE BEGINNING OF THIRD (3 RD BLOCK ZOOLOGY) OR THE BEGINNING OF FOURTH (4 TH BLOCK ZOOLOGY).

DEADLINE? PLEASE COMPLETE THIS TASK BY MONDAY, AUGUST 13. Ms. Bourn will send a Remind message about these forms, but remember, do NOT tell her if you have or have NOT, brought signed forms to me.

APPENDIX F Minor Assent Form

ORI | Office of Research Integrity

INSTITUTIONAL REVIEW BOARD

MINOR ASSENT FORM

MINOR ASSENT PROCEDURES

This document must be completed by the Principal Investigator and signed by each assenting minor.

- The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval.
- Parental consent must be obtained before soliciting the assent of any minor participating in the study.
- Signed copies of the IRB approved assent form should be provided to a parent or guardian of every assenting minor.

Last Edited June 1st, 2018

Today's date:8/8/2018

PROJECT INFORMATION

Project Title: Classroom Response Systems: Does Instantaneous Feedback Affect Students' Knowledge and Self-Efficacy in a Secondary Science Course		
Principal Investigator: Shani Bourn	Phone: 228-467-2251	Email: sbourn@hancockschools.net
College: The University of Southern Mississippi	Department: Center for Science and Math Education	

RESEARCH DESCRIPTION

1. **Why am I being asked to participate?**

   The purpose of this study is to see if instantaneous feedback with classroom response systems increases student self-confidence and content knowledge. Feedback helps promote student confidence, student learning, and understanding. This study may provide insight to the academic benefits of this type of technology in the classroom.

2. **What will I have to do?**

   During the semester, both zoology classes will be included. A self-efficacy (self-confidence) questionnaire will be completed at the conclusion of week one and week16 of the semester. During the first unt, Block 3 will have instantaneous feedback with their Q6 remotes with three practices and their unit test. Block 4 will also use their Q6 remotes, but without the instantaneous feedback. During the second unit, Block 4 will have instantaneous feedback with their Q6 remotes, while Block 3 will not. This "flipping" will occur until Week 16 of the semester.

3. **What do I get if I agree to participate?**

   You will have the unique opportunity of participating in a disseration study and possibly experience gains in content knowledge.

4. **Can anything bad happen if I participate?**

   There will be no anticipated side effects participating in this study.

5. **Who will get to see information about me?**

   Ms. Karl and myself will be the only people that may be able to see your information. Both of us, being

information that develops during the project will be provided if that information may affect the willingness to continue participation in the project.

Questions concerning the research, at any time during or after the project, should be directed to the Principal Investigator with the contact information provided above. This project and this consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5116, Hattiesburg, MS 39406-0001, 601-266-5997.

Parent or Guardian of Research Participant	**Person Explaining the Study**
Date	8/12/18 **Date**

APPENDIX G Parental Consent Form

ORI | Office of Research Integrity

INSTITUTIONAL REVIEW BOARD

PARENTAL CONSENT FORM

PARENTAL CONSENT PROCEDURES

This document must be completed by the Principal Investigator and signed by the parent or guardian of each potential research participant.

- The Project Information and Research Description sections of this form should be completed by the Principal Investigator before submitting this form for IRB approval.
- Signed copies of the long form consent should be provided to a parent or guardian of every participant.

Last Edited May 22nd, 2014

Today's date:7/2018

PROJECT INFORMATION

Project Title: Classroom Response Systems: Does Instantaneous Feedback Affect Students' Knowledge and Self-Efficacy in a Secondary Science Course		
Principal Investigator: Shani Bourn	Phone: 228-456-2251	Email: sbourn@hancockschools.net
College: The University of Southern Mississippi	Department: Center for Science and Math Education	

RESEARCH DESCRIPTION

1. **Purpose**:

The main purpose of this research study is to provide data for the academic community regarding an instructional strategy with the instantaneous feedback feature of classroom response systems and measure the increase in student self-efficacy due to instantaneous feedback. The results of this research study will provide measured evidence of student knowledge with concepts and self-efficacy as a result of implementation of the instantaneous feedback feature with classroom response systems.

2. **Description of Study:**

A quasi-experiental design, during weeks 2-16 of the semester,only one class of students will receive instantaneous feedback, the treatment, with their CRS during an instructional unit with two or three formative assessments and end-of-unit summative assessment. These assessments will measure content knowledge gains with a raw score. The following instructional unit the treatment of instantaneous feedback with CRS will switch to the other class, meaning the first class will not receive instantaneous feedback with CRS. The third instructional unit that begins during the fourth week of instruction will switch the treatment of instantaneous feedback with CRS again to the first class with formative and summative assessments. This quasi-experimental design will ensure ability groups and intelligence levels will not factor as an influence on the outcome of measured assessment raw scores. This alternating of classes with students that receive treatment of instantaneous feedback with their CRS will continue until week 16 of the fall semester. Data will be collected through a total of 12 units of instruction, totaling 28 formative assessment scores and 12 summative assessment scores from each class. Self-efficacy questionnaire will be administered as a pre-test at the beginning of the course, end of week one, as baseline data. A final administration of the same questionnaire will be completed by students at the conclusion of their final unit with instantaneous feedback of classroom response systems (CRS), weeks 15-16 of the semester.

3. **Benefits:**

Participants may experience increased gains in content knowledge and self-efficacy due to instantaneous feedback feature with CRS. Also, hopeful students will realize the value of their contribution to this research and the effect it may have in improving instructional methods.

4. **Risks:**

Risks to individual students is minimal, requiring signed parental consent. Student assent must also be completed.

5. **Confidentiality:**

During the initial class meeting, a certified teacher will discuss with each student the goals of the study and review the parental consent form and student assent form. Participants will have an opportunity to ask questions and express concerns regarding the study. If a student decides to participate, he/she will be provided first a parental consent form. Once signed parental consent form is returned to certified teacher research assistant, student will receive a student assent form that will explain their rights. Participant rights include: the right to withdraw from the study or to refuse answer questions at any time with no penalty. All information will be kept confidential. Participants will first, turn in signed parental consent forms and later, completed assent forms to certified teacher research assistant within three calendar days, prior to beginning of data collection. To prevent researcher bias, researcher will receive completed and signed parental consent forms and student assent forms after the conclusion of semester to determine which student data is eligible for inclusion of dissertation study. To maintain a licensed member of the MS State Department of Education, our MS Educator Code of Ethics, Standard 9, specifically addresses Maintenance of Confidentiality, must be followed. The MS Educator Code of Ethics, 37-17-6 MS Code of 1972, and FERBA are ongoing professional development topics within each academic school year as required by State of MS Department of Education regulations.

6. **Alternative Procedures:**

No alternative procedures will be administered to individual students.

7. **Participant's Assurance:**

This project has been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations.

Any questions or concerns about rights as a research participant should be directed to the Manager of the IRB at 601-266-5997.Participation in this project is completely voluntary, and participants may withdraw from this study at any time without penalty, prejudice, or loss of benefits.

Any questions about the research should be directed to the Principal Investigator using the contact information provided in Project Information Section above.

PARENTAL CONSENT INFORMATION	
Participant's Name:	Participant's Age:
Parent or Guardian's Name:	
Person Soliciting Parental Consent:	

AGREEMENT TO ALLOW PARTICIPATION IN RESEARCH

Consent is hereby given to participate in this research project. All procedures and/or investigations to be followed and their purpose, including any experimental procedures, were explained. Information was given about all benefits, risks, inconveniences, or discomforts that might be expected.

The opportunity to ask questions regarding the research and procedures was given. Participation in the project is completely voluntary, and participants may withdraw at any time without penalty, prejudice, or loss of benefits. All personal information is strictly confidential, and no names will be disclosed. Any new

licensed by the MS Department of Education must abide by our MS Educator Code of Ethics, 37-17-6 MS Code of 1972, and FERBA. All of which have confidentiality regulations we must follow.

6. **What if I do not want to participate?**

There will be no effect to your instruction if you do not want to participate. There will no difference in instruction, grading, or opportunities regarding this class.

7. **Who may I contact if I have other questions or concerns about my participation?**

This project has been approved by the Institutional Review Board. Its job is to protect research participants. Questions or concerns about your participation should be directed to the Manager of the IRB at 601-266-5997.

ASSENT TO PARTICIPATE IN RESEARCH

Participant's Name:	Participant's Age:
Person Soliciting Assent:	

Check one of the following (to be completed by the person soliciting assent):

☒ In my opinion this minor is able to provide informed assent (proceed to Agreement to Participate).
☐ In my opinion this minor is unable to provide informed assent for the following reason(s) (do not proceed):

AGREEMENT TO PARTICIPATE

I agree to participate in this research project. The project has been fully explained to me and I was given the chance to ask any questions I have about it. I understand that I can stop participating at any time.

Research Participant	**Person Soliciting Assent**
	8/12/18
Date	**Date**

APPENDIX H Research Collaboration's Self-Efficacy Questionnaire

Self-Efficacy Questionnaire

Please **CHECK ONE** response that best describes you. Be honest, since the information will be used to help you in school and also help you become more prepared for college and careers. There are no right or wrong answers!

Student ID_____ **Date** _____

	Not very like me → Very like me				
	1	2	3	4	5
1. I can learn what is being taught in class this year.	☐	☐	☐	☐	☐
2. I can figure out anything if I try hard enough.	☐	☐	☐	☐	☐
3. If I practiced every day, I could develop just about any skill.	☐	☐	☐	☐	☐
4. Once I've decided to accomplish something that's important to me, I keep trying to accomplish it, even if it is harder than I thought.	☐	☐	☐	☐	☐
5. I am confident that I will achieve the goals that I set for myself.	☐	☐	☐	☐	☐
6. When I'm struggling to accomplish something difficult, I focus on my progress instead of feeling discouraged.	☐	☐	☐	☐	☐
7. I will succeed in whatever career path I choose.	☐	☐	☐	☐	☐
8. I will succeed in whatever college major I choose.	☐	☐	☐	☐	☐
9. I believe hard work pays off.	☐	☐	☐	☐	☐
10. My ability grows with effort.	☐	☐	☐	☐	☐
11. I believe that the brain can be developed like a muscle.	☐	☐	☐	☐	☐
12. I think that no matter who you are, you can significantly change your level of talent.	☐	☐	☐	☐	☐
13. I can change my basic level of ability considerably.	☐	☐	☐	☐	☐

Gaumer Erickson, A.S., Soukup, J.H., Noonan, P.M., & McGurn, L. (2016). Self-Efficacy Questionnaire. Lawrence, KS: University of Kansas, Center for Research on Learning.

APPENDIX I Teacher Lesson Plan Subject: Zoology I (1st Nine Weeks)

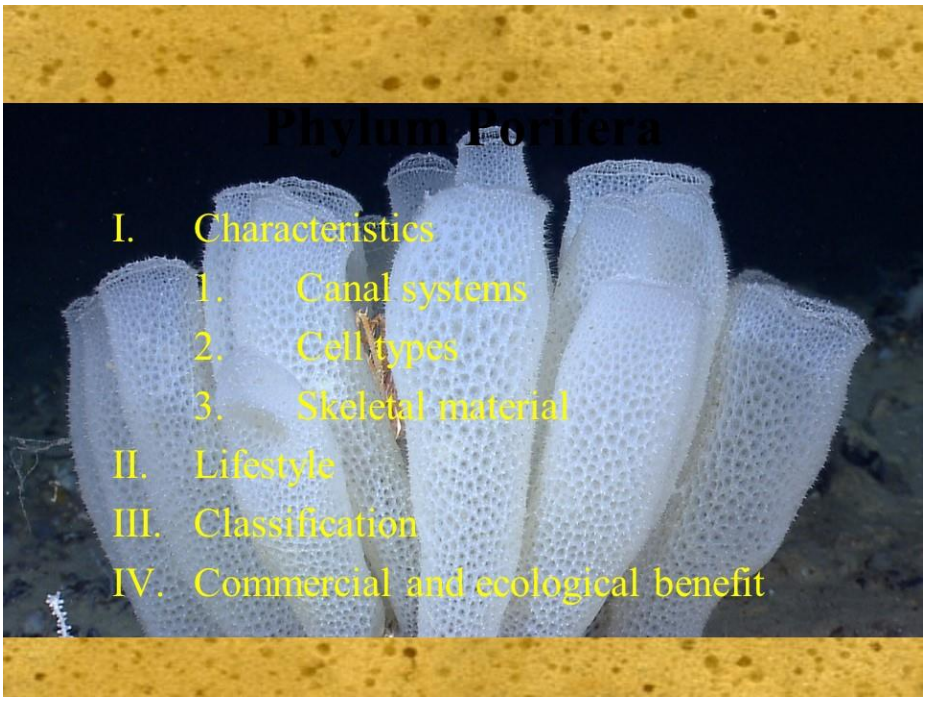
8/16-8/17/2018	Activities	Resources
ZOO.2 Students will understand the structure and function of **phylum Porifera** and phylum Cnidaria and how each adapts to their environments.	**TH** –UNIT 1 SUM TEST Chara of Sponge article Porifera PPT **F –** Porifera PPT, Porifera video clips, Porifera A(Q)	Chara of sponge article, Porifera PPT & student notes, Porifera A(Q)
8/20-8/24/2018	Activities	Resources
ZOO.2 Students will understand the structure and function of **phylum Porifera** and phylum Cnidaria and how each adapts to their environments.	**M –** Porifera chara lab **T** – Porifera PPT & video Clips, Porifera B(Q) **W** – sponge article, review for Porifera test, Coral Seas video **TH** – PORIFERA TEST(Q), Cnidaria PPT and student notes **F** – Cnidaria PPT, Coral Seas video	Porifera lab, Porifera PPT & student notes, Porifera B(Q), sponge article, Coral Seas video ?'s, Porifera Test, Cnidaria PPT and student notes
8/27-8/31/2018	Activities	Resources
ZOO.2 Students will understand the structure and function of phylum Porifera and **phylum Cnidaria** and how each adapts to their environments.	**M** – Cnidaria lab **T** – Cnidaria PPT, Cnidaria A(Q), Coral Seas video **W** – Cnidaria B(Q), Amazing Jelly video **TH** – Cnidaria article, review for Cnidaria test, Amazing Jelly video **F** – CNIDARIA TEST(Q), worm disease project	Cnidaria lab, Cnidaria PPT & student notes, Cnidaria A, Cnidaria B, Cnidaria article, Cnidaria Test, worm disease project

Teacher Lesson Plan Subject: Zoology I (1st Nine Weeks)

9/6-9/7/2018	Activities	Resources
ZOO.4 Students will describe the evolution of structure and function of phylum Platyhelminthes, phylum Nematoda, and phylum Annelida.	**TH** – worm disease research **F** – worm disease research	worm disease project
9/10-9/14/2018	Activities	Resources
ZOO.4 Students will describe the evolution of structure and function of phylum Platyhelminthes, phylum Nematoda, and phylum Annelida.	**M** – Helminth PPT, worm disease student PPT, Helminth A(Q) **T -** Helminth PPT, worm disease student PPT, Helminth B(Q) **W-** worm dissections **TH** – Helminth C(Q), Helminth test review, worm videos **F** – HELMINTH TEST (Q)	Helminth PPT & student notes, student worm disease PPT, Helminth A, Helminth B, Helminth C, Helminth Test
9/17-9/21/2018	Activities	Resources
ZOO.3 Students will understand the structure and function of phylum Mollusca, and how they adapt to their environments.	**M** – Mollusk PPT & videos, Mollusk A(Q) **T** – Mollusk PPT & videos, Mollusk B(Q) **W** – clam dissection **TH** – Colossal squid video, Mollusk C(Q) **F** – Mollusk C(Q), review for Mollusk test	Mollusk PPT & student notes, Mollusk A, Mollusk B, clam dissection, Mollusk C

APPENDIX J Teacher Powerpoint presentations for Zoology I

Teacher powerpoints have been modified to exclude supplemental pictures and video clips (Mississippi Deparment of Education, 2017; Hickman & Roberts, 1



Three types of canal systems

- **Asconoid – simplest**
  - **Water enters ostia, flows through spongocoel, exits osculum**
- **Synconoid – more complex, incurrent canals**
  - **Water enters canal, radial canal, spongocoel, then osculum**
- **Leuconoid – most complex, flagellated chambers**
  - **Water enters ostia, flagellated chambers, excurrent pores, then osculum**

Three Basic Types of Cells

- **Pinacocytes – flat, thin, covering**
  - **Collectively called pinacoderm**
  - **"special" Porocytes perforated**
- **Choanocytes – "collar cells"**
  - **Capture and digest food**
  - **Exposed flagella and collar of microfibrils**
- **Amebocytes – "handyman"**
  - **Free moving**
  - **Food reserves, aid in digestion, carry pigment, form reproductive cell, or secrete skeletal material**

Three types of Skeletal Material

- **Calcium carbonate spicules**
  - **May be one, three, or four rays**
- **Silica spicules**
  - **May be one, two, four, or six rays**
- **Spongin**
  - **Tough, branching protein fiber, supports sponge alone or with spicules**

Lifestyles

- **All life functions depend on water current**
- **Filter feeders**
- **May reproduce sexually or asexually**
  - **Budding (portion breaks off)**
  - **Gemmules (internal buds)**
  - **Archaeocytes form sperm and ovum**
- **Some Monoecious (both and male sex cells) and some Dioecious (separate sexes)**

Classification

- **Separated into classes based on skeletal type and type of canal system**

Class	**Skeletal material**	**Canal**	**Examples**
Calcispongiae (Calcarea)	$Ca(CO)_3$	all	Scypha
Hyalospongiae	Si –6 ray	L or S	**Venus Flower Basket**
Demospongiae (1 family fresh)	Spongin &/or Si	L	Spongilla & Bath sponge
Sclerospongiae	all	L	Astrosclera & Caves, deep

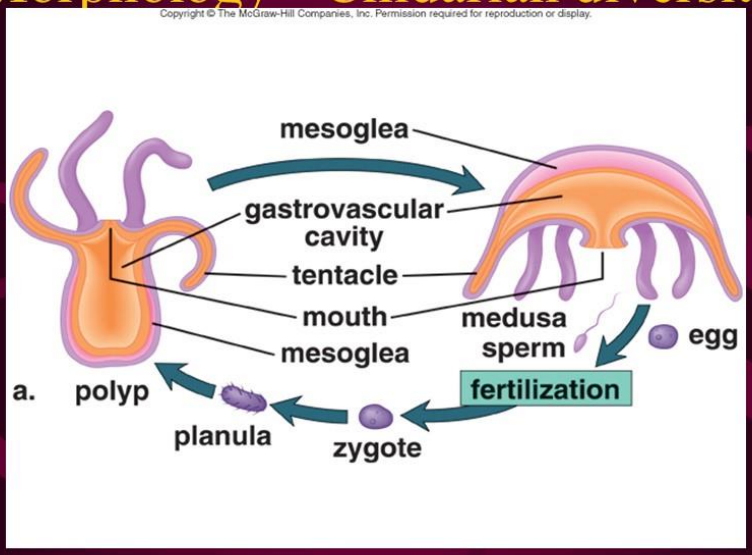
Commercial & Ecological Benefits

- Bath sponges
- Regenerative powers (medicine)
- Many animals live as commensals or parasites in or on sponges
- Some animals use sponges for camouflage and protection
- Provide food for some reef fishes
- http://oceanexplorer.noaa.gov/explorations/03bio/background/plan/media/discodermia.html

Characteristics

- Diverse – 10,000 species, sea anemones, coral, hydra, jellyfish
- Mostly marine, all aquatic
- Radial symmetry – sometimes bilateral
- Two germ layers – diploblastic
- Acoelomate with body sac plan
- Cnidocytes – contain stinging structures
- Tissue level of organization

Morphology - Cnidarian diversity



Cnidocytes

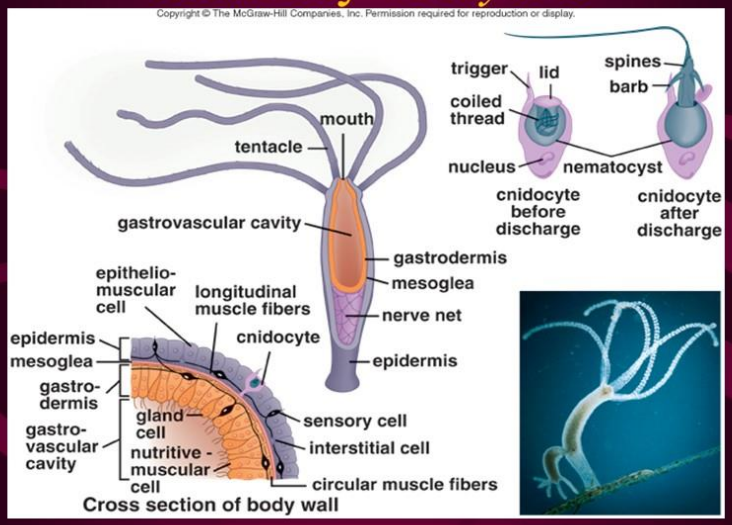
- Specialized cells for prey capture and defense
- Contain stinging capsules called nematocysts
- Have a trigger, which when released discharges the nematocysts which harpoons or lassos
- No other organisms contain cnidocytes

Class	Form	Structure	Number	Example
Cubozoa	Medusa dominant	Thick mesoglea, no velum	single	Box jelly, Sea wasp
Hydrozoa	Polyp dominant	Single gastrovascular cavity, velum, Thin mesoglea	Single or colonial	Hydra, Obelia, Portuguese man o war
Scyphozoa "cup"	Medusa dominant	Thick mesoglea, no velum	single	jellyfish
Anthozoa "flower"	No medusa stage	Gastrovascular cavity divided by septa	Often colonial	Sea anemone, coral

• Hydra

- A *hydra* polyp has an outer layer of epidermis derived from ectoderm and an inner layer called *gastrodermis* derived from endoderm.
- *Mesoglea* lies between the two layers and contains a *nerve net* that communicates with muscle fibers so that the animal is able to move.
- Digestion begins in a *gastrovascular cavity* and finishes in *gastrodermal cells*.
- Nutrients and gases are distributed from layer to layer by diffusion.

Anatomy of *Hydra*



Phylum Ctenophora

- Rows of cilia, no cnidocytes
- Triploblastic, sac body plan
- Colloblast – sticky to catch prey
- 2 species found in MS Sound

Classification

- **Phylum – Cnidaria (formerly Coelenterata)**
  - **Corals, sea anemones, hydras, jellyfishes and their relatives**
- **Class – Anthozoa**
- **Three subclasses:**
  1. **Octocorallia – eight pennate tentacles – soft corals- mostly colonial**
  2. **Zoantharia – six pennate tentacles – hard/stony corals – black corals – solitary or colonial**
  3. **Tabulata – extinct colonial corals**

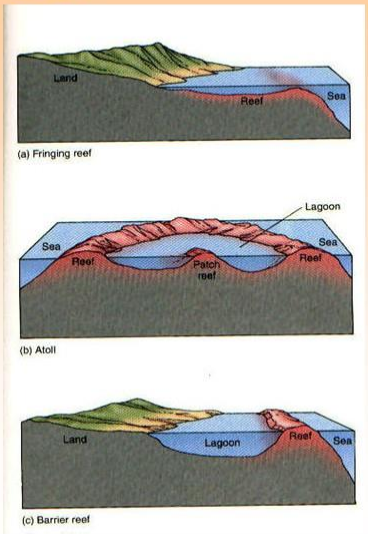
***Colonial corals – individual coral polyps within a colony connected by common tissue**

General Information

- Deposits of calcium carbonate produced primarily by coral polyps and encrusting algae
- 0.1% of Earth's surface covered by coral reefs
- Found in nutrient poor areas (oligotrophic waters)
- Highest productivity of all marine environments with greatest diversity
- Earliest reefs developed two billion years ago – colonies of calcareous algae

Types of Reefs

- Fringing – border shorelines of continents and islands in tropical seas – S. Pacific Hawaiian Islands
- Barrier – form when land masses sink and fringing reefs become separated from shorelines by wide channels – Caribbean and Indo-Pacific
- Atoll – form when small islands disappear below the ocean surface – Indo-Pacific



Reef Composition

- Hard corals – secrete calcium carbonate skeletons
- Boring organisms – break down the coral skeletons – attack dead coral
  - sponges, worms and bivalves
- Grazers –
  - parrotfish and sea urchins

Habitat Requirements

- Warm, clear, shallow, tropical, marine water
  - 68 degree Fahrenheit isotherm
  - Light penetration for zooxanthellae
    - Usually not found at depths with light levels below 2% of the average surface sunlight
  - Salinity 32-35 ppt or psu

What They Do for Us

- Provide shorelines
- Nurseries
- Protein source
- Food, shelter and protection
- Provide jobs
- Source of medicine
- Study and enjoyment

What We Do for Them

- Pollute them
- Fish them in destructive ways
- Mine them
- Smother them
- Ground boats on them
- Drop anchors, step, and drag dive gear on them
- Chop them down for our commercial use

Diet

- Zooplankton (tiny drifting animals or small fishes
- Organic debris

Major Producers

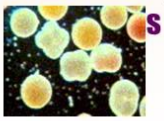
- Zooxanthellae –
  - Yellow-brown algae
  - Live symbiotically within coral
    - Food (photosynthesi
      in exchange for shel
      protection and acce
      to light

Methods of Eating

- Chemoreception – detecting prey
- Nocturnal feeders
- Tentacles move food to mouth
- Secrete films of mucus to collect fine organic particles
- In reef-building corals, mobile stomach filaments can capture and digest food particles
- Excretes solid wastes through mouth

Reproduction

- Sexual –
  - Internal fertilization
  - External fertilization
  - Hermaphroditic
  - Synchronous spawning
  - Once settled on hard substrate, polyp
    s



- Asexual-
  - Environmental dislodging/relocation to new part of reef
  - New colonies split to form separate colonies
  - Budding – pinching off of parent polyp to form
    al

Growth

- Shallow water colonies – heavily branched
- Deep water colonies – sheets or plates
  - More efficient use of lower light intensities
- Reef development more abundant in areas prone to strong wave action
  - Food, nutrients and oxygen
  - Prevent sediment from settling
- Most grow on hard substrate

Growth

- Depends on:
  - light intensity
  - water temperature
  - salinity
  - turbidity
  - food availability
  - competition for space
  - predation
- Upward growth generally between .5 to 4 inches/year

Limiting Factors

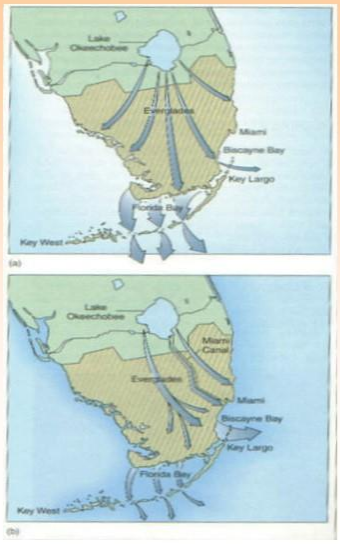
- Sedimentation reduces light and smothers corals
- Limited upward growth – more than 1-2 hours sun exposure can result in death

Problems

- Coral Bleaching
  - Whitening due to loss of zooxanthellae
  - Big changes in coral's environment cause the algae to abandon ship
    - They may come back when things get back to normal

Problems

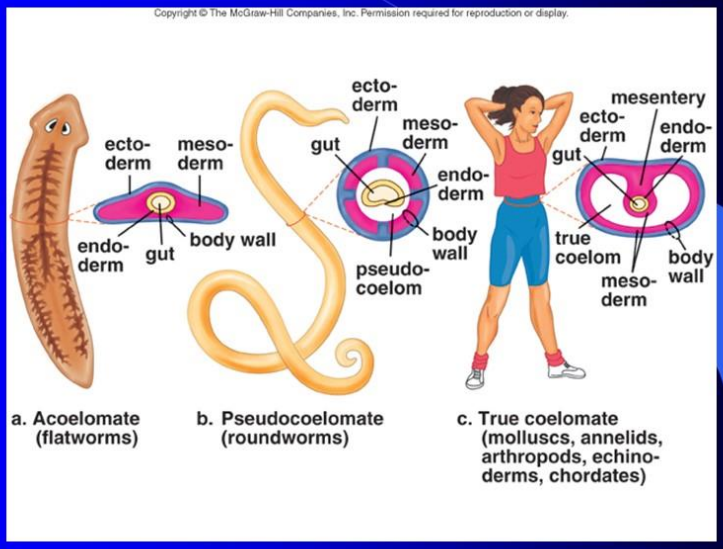
- Rivers draining into prime areas for coral



Helminthology

- Phylum Platyhelminthes - flatworms
- Phylum Nematoda - roundworms
- Phylum Annelida – segmented worms

Coelom structure and function



Overview of flatworms

- Flatworms are characterized by the tissue level of organization and a sac body plan.
- These acoelomates have three germ layers, and have all organs except respiratory and circulatory organs.
- The flat body facilitates diffusion of oxygen and other molecules from cell to cell.

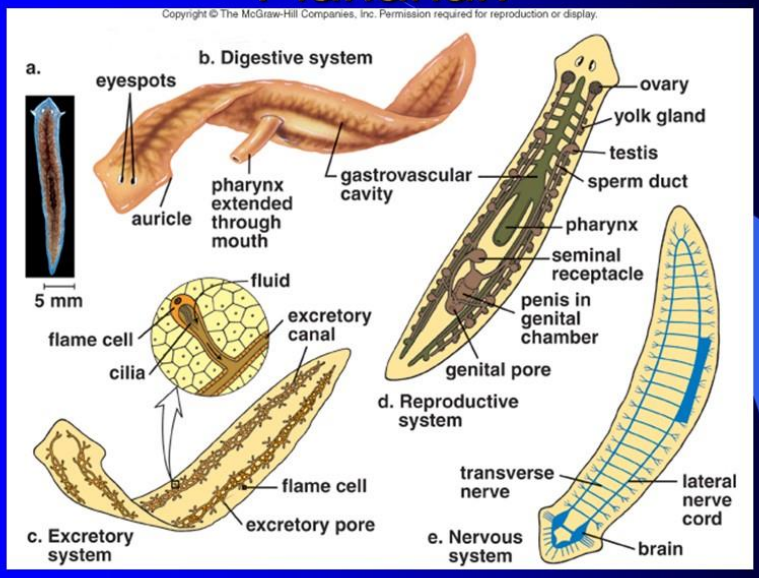
Flatworms

- Planarians – free living carnivores
- Mongenetic flukes – single host ectoparasites
- Flukes – mutiple hosts endoparasites
- Tapeworms – vertebrate endoparasites

Planarians

- *Planarians* are freshwater, free living, flatworms.
- *Flame cells* function in excretion.
- The small brain extends to a ladder arrangement of nerves.
- Light-sensitive organs (eyespots) are in the head; planarians exhibit *cephalization*.
- One organism has both male and female sex organs – they are *hermaphroditic*.

Planarian



Parasitic Flatworms

- Flukes and tapeworms are two classes of parasitic flatworms; both have intermediate hosts.
- *Flukes* are oval to elongate and have suckers at the anterior end.
- Blood flukes cause *schistosomiasis*; other flukes infect the digestive tract, bile duct, and lungs.
- A *tapeworm* has an anterior *scolex* with hooks and suckers to hold itself inside the gut.

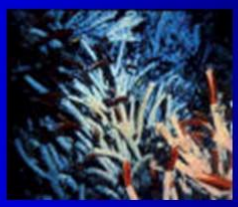
Roundworms

- *Roundworms* have the tube-within-a-tube plan; they are prevalent in soil and some parasitize animals and plants.
- The *pseudocoelom* is a body cavity incompletely lined with mesoderm.
- The fluid-filled interior forms a *hydrostatic skeleton*.
- Most species of roundworms have separate males and females.

Phylum Annelida

- Polychaetes – mostly marine
- Earthworms – some freshwater, some ectoparasites
- Leeches






Annelids

- *Annelids* are segmented both externally, and internally by partitions called *septa*.
- Annelids have a *hydrostatic skeleton*, and partitioning of the coelom permits each body segment to move independently.
- The tube-within-a-tube body plan allows the digestive tract to have specialized organs.

Marine Worms

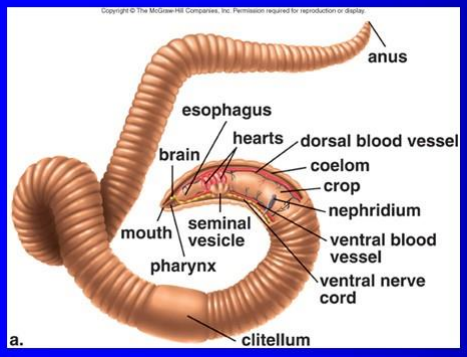
- *Polychaetes* are marine worms with paddlelike *parapodia* at the side of each segment.
- Some polychaetes are sessile *tube worms*.
- A *clam worm* is a predaceous marine worm with a defined head region.
- During breeding seasons, some worms form sex organs in special segments and shed these segment during breeding.

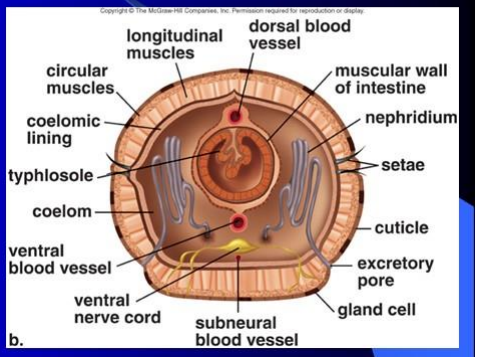
Earthworms

- *Earthworms* are *oligochaetes* having few *setae* per segment.
- Most scavenge for food in the soil and the moist body wall functions in gas exchange.
- When muscles contract in each segment, setae anchor in the soil, and aid locomotion.
- Five "hearts" pump blood and a branch blood vessel reaches each segment.
- These worms are hermaphroditic.

- Segmentation in earthworms is evidenced by:
  - Body rings
  - Coelom divided by septa
  - Setae on most segments
  - Ganglia and lateral nerves in each segment
  - Nephridia in most segments
  - Branch blood vessels in each segment

Earthworm, *Lumbricus*





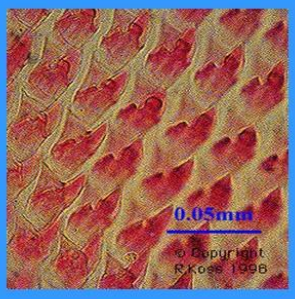
Leeches

- Most *leeches* are fluid feeders that attach themselves to open wounds using suckers.
- Bloodsuckers, such as the medicinal leech, can cut through tissue.
- An anticoagulant (*hirudin*) in their saliva keeps blood from clotting.

Phylum Mollusca

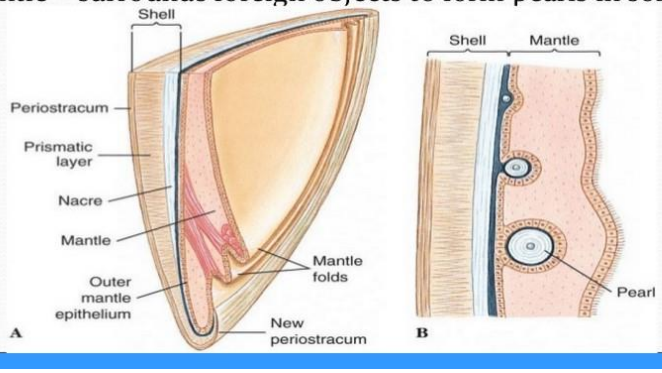
Examples include snails, slugs, chitons, octopus, squid, elephant tusk shells, whelks, scallops, clams, mussels

"Claim to fame"- radula to scrape food



Shells

- When present, the calcareous **shell** is secreted by the **mantle** and is lined by it. It has 3 layers:
  - **Periostracum** – outer organic layer helps to protect inner layers from boring organisms.
  - **Prismatic layer** – densely packed prisms of calcium carbonate.
  - **Nacreous layer** – iridescent lining secreted continuously by the mantle – surrounds foreign objects to form pearls in some.



Characteristics of Molluscs

A mollusc body typically contains a *visceral mass*, a *mantle*, and a *foot*.

Molluscan groups are distinguished by a modification of the foot.

In *gastropods*, the foot is ventrally flattened.

In *cephalopods*, the foot has evolved into tentacles about the head.

More Characteristics

- Bilateral symmetry, unsegmented
- Coelom mainly limited around the heart
- Open circulatory system (closed with cephalopods) with three chambered heart
- Gas exchange by gills, lungs, mantle, or body surface
- One or two kidneys (metanephridia)
- Nervous system with brain and nerve ring in some
- Sensory organs of touch, smell, taste, equilibrium, and vision (esp. cephalopods)

Class	**Examples**	**Foot**	**Shell**		
Polyplacophora	chiton	Broad & flat	8 plates		
Scaphopoda	Elephant tusk shells	conical	Tubular open at both ends		
Gastropoda	Snail slug whelks	Large & flat	Coiled-not or absent		
Bivalvia Pelecypoda	Scallops mussels	Wedge shaped	Two valves		
Cephalopoda	Squid octopus nautilus	Into a funnel	Reduced internal or absent		

Bivalves

***Bivalves*, such as clams and relatives, have a hatchet foot and are filter feeders.**

Water enters by an *incurrent siphon*.

Food trapped on the gills is swept toward the mouth.

A coelom is present but reduced.

The circulatory system pumps blood through sinuses.

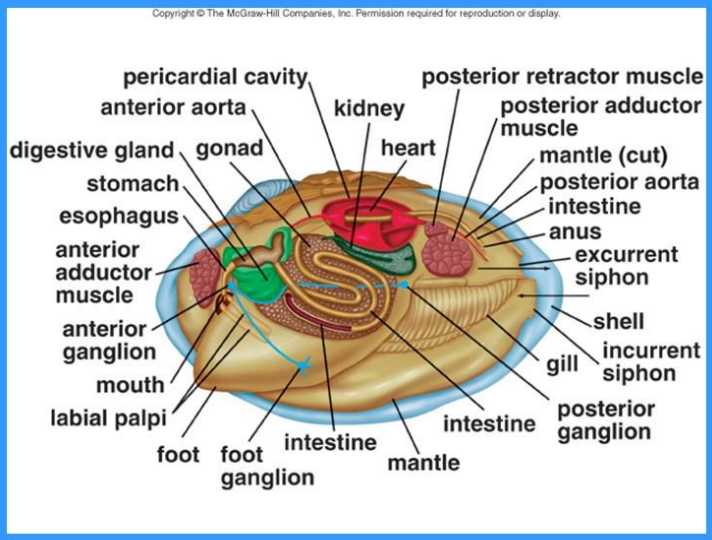
In bivalves, there is no head and three pairs of ganglia control the bivalve.

The digestive system of a clam includes a mouth with *labial palps*, an esophagus, a stomach, and an intestine, which coils about the visceral mass and then is surrounded by the heart as it extends to the anus.

The anus empties at an *excurrent siphon*.

Sexes are usually separate and the gonad is located around the coils of the intestine.

Clam



Squids **are cephalopods that display marked cephalization, move rapidly by *jet propulsion*, and have a *closed circulatory system*.**

The camera-type eye of cephalopods evolved separately from the eye of vertebrates.

In cephalopods, the brain is formed from a fusion of ganglia, and nerves leaving the brain supply the body.

Rapid secretion from an *ink gland* helps cephalopods escape enemies.

Arthropods

- ***Arthropods*** are the most varied and numerous of animals
- Eucoelomate protostomes, bilateral symmetry, metameric body
- Complex muscular system
- Open circulatory system
- Sexes usually separate
- Three body regions – ***head***, ***thorax***, and ***abdomen*** – with specialized appendages in each region, and a well-developed nervous system characterize this group.

Success of Arthropods

- Versatile exoskeleton
- Segmentation and appendages for more efficient locomotion
- Air piped directly to cells
- Highly developed sensory organs
- Complex behavior patterns
- Reduced competition through metamorphosis

Classifi-cation	Examples	Classification	Examples
Subphylum Trilobita	trilobites	Subphylum Crustacea	Crab, shrimp, lobster
Subphlum Chelicerata	1st pair - chelicerae	Subphylum Uniramia	Unbranched appendages
Class Merostoma	Horseshoe crabs	Class Diplopoda & Chilopoda	Millipedes & centipedes
Class Arachnida	Scorpion, spider, mite, tick	Class Insecta	insects

Subphylum Crustacea

Class	Examples
Branchipoda	Brine shrimp, water fleas
Maxillopoda	Ostracods (seed shrimp), copepods, barnacles
Malacostraca	Isopods, amphipods, decapods (lobsters, crayfish, shrimp, & crabs)

Subphylum Trilobita

- Extinct for 200 million years
- Bottom dwellers, probably scavengers
- Could roll up like pill bugs

Subphylum Chelicerata

Class Merostomata

- Five species alive today
- Unsegmented with carapace, abdomen with book gills, and long telson
- Used in medicine for microbial testing

Subphylum Crustacea
Crustaceans

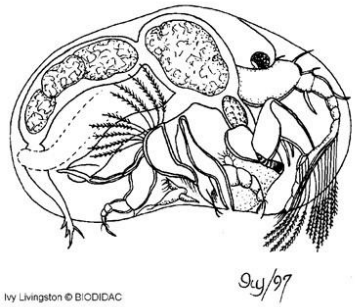
- ***Crustaceans*** are largely marine and have a head that bears compound eyes, two pair of antennae, and specialized mouth parts.
- Five pairs of ***walking legs*** include a first pair of pinching claws.
- In the crayfish, head and thorax are fused into a ***cephalothorax*** which is covered on the top and sides by ***carapace***.
- The abdominal segments have ***swimmerets***.

Class Branchipoda

- Reduced first antennae
- Legs are flattened, leaflike and are the chief respiratory organs
- Legs may also be used in suspension feeding and/or locomotion

Class Maxillopoda

- Basically have five cephalic, six thoracic, and four abdominal somites plus a telson



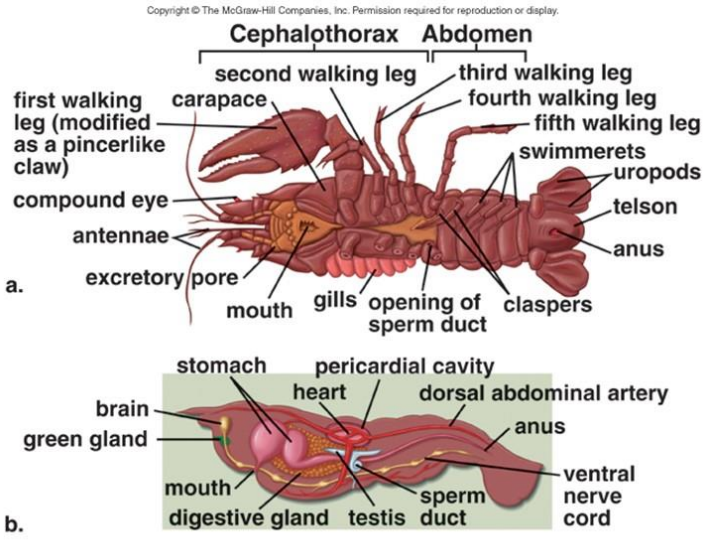
Class Malacostraca

- Largest class of Crustacea and greatest diversity
- Trunks has eight thoracic and six abdominal somites, each with a pair of appendages

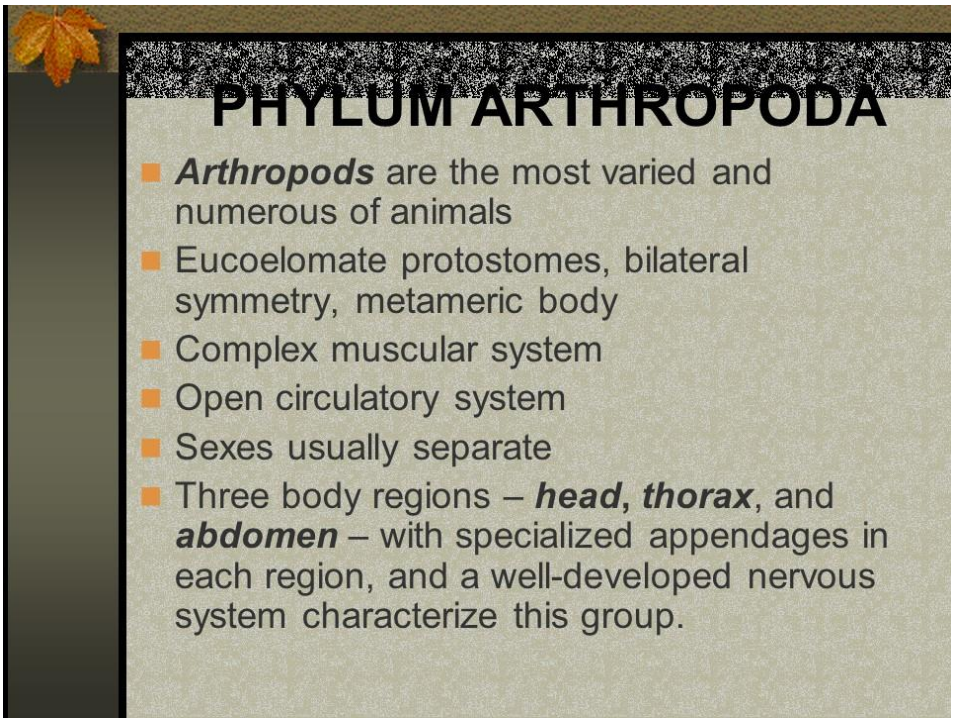
How did it get here?

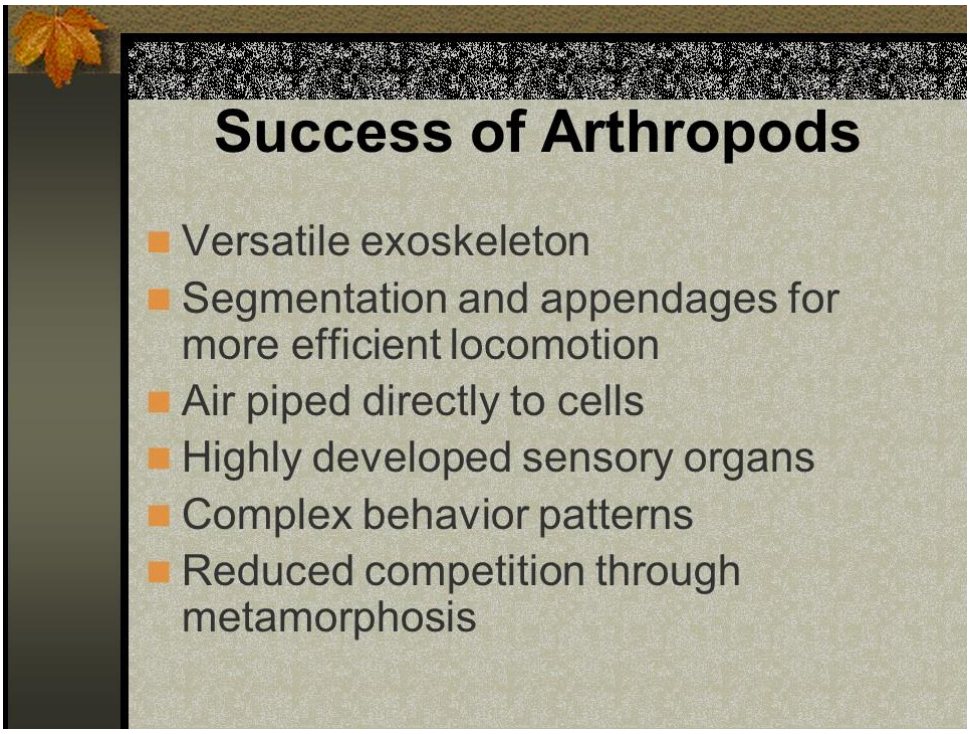
- Introductions of tiger shrimp into the south US are most likely by escapement from aquaculture facilities (storms and hurricanes) or through migration from areas where tiger shrimp already established in the wild.
- Less probable, other pathways of introduction (e.g. ballast water discharge) are also possible.hurricanes.

Male crayfish, *Cambarus*



- The crayfish has an open circulatory system in which the heart pumps blood into a ***hemocoel*** consisting of sinuses where the ***hemolymph*** flows about the organs.
- Respiration takes place by gills under the hard carapace, and there is a ventral solid nerve cord.
- Sexes are separate in the crayfish.





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Class Merostoma	Horseshoe crabs	Class Diplopoda & Chilopoda	Millipedes & centipedes
Class Arachnida	Scorpion, spider, mite, tick	Class Insecta	insects

Class Hexapoda (Insecta)

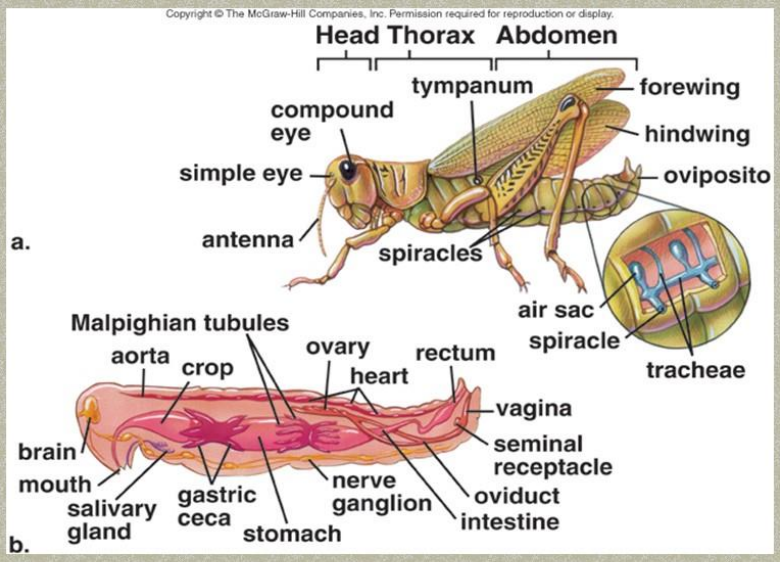
- The head of an *insect* usually bears a pair of antennae, compound eyes, and simple eyes.
- The thorax bears three pairs of legs and up to two pairs of wings, and the abdomen contains most of the internal organs.
- The insect exoskeleton is lighter and contains less chitin than that of many other arthropods.

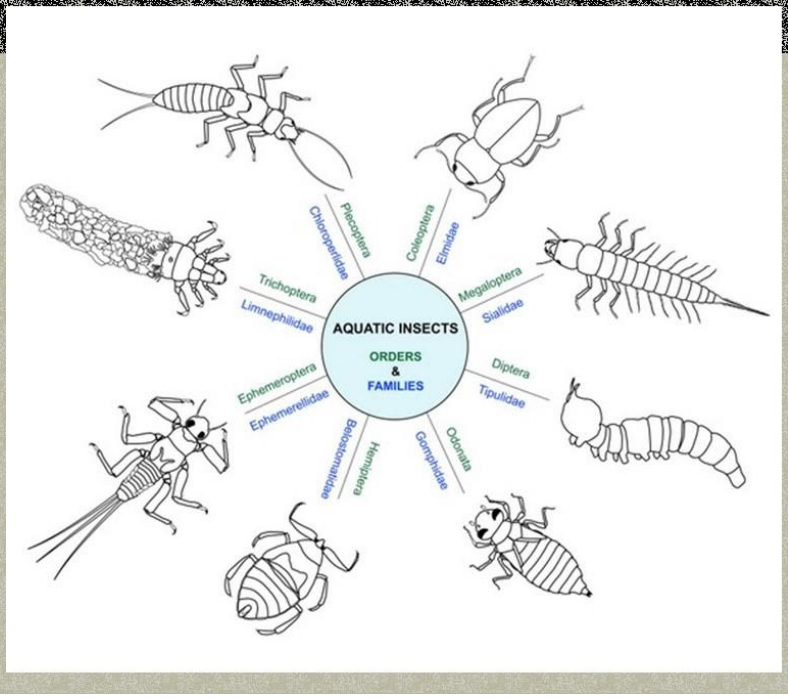
NOT a mosquito hawk, CRANE FLY

- *Grasshoppers* are examples of insects adapted to a terrestrial life; they respire by *tracheae* and have wings that allow them to evade enemies; the third pair of legs is suitable for jumping.
- There is a *tympanum* for the reception of sound waves and a male penis for passing sperm to the female without desiccation.

- *Malpighian tubules* function in excretion in grasshopper.
- Grasshoppers undergo *gradual metamorphosis or hemimetabolous* from nymph to adult.
- Butterflies undergo *complete metamorphosis or holometabolous*, changing from larva to pupa to adult.

Female grasshopper





Class Diplopoda

Includes millipedes (herbivores and two sets of walking legs per segment)

Class Chilopoda

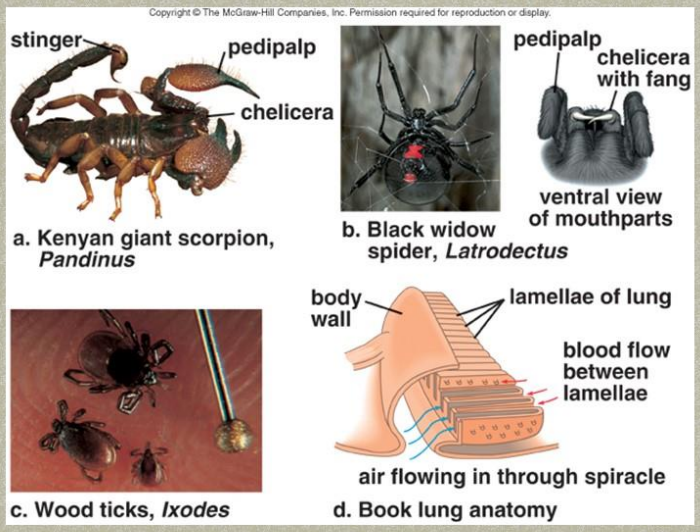
Includes centipedes (carnivorous predators with one set of legs per segment)

Class Arachnida

- The *arachnids* include terrestrial spiders, scorpions, ticks, and mites.
- The cephalothorax bears six pairs of appendages: the *chelicerae* and the *pedipalps*, and four pairs of walking legs.
- *Scorpions* are the oldest terrestrial arthropods.
- *Ticks* and *mites* are parasitic.

- *Spiders* are well-adapted to life on land and have Malphigian tubules – they secrete uric acid, helping to conserve water.
- Spiders spin *silk* used in various ways.
- Where spiders spin webs, the type of web is a feature that demonstrates the evolutionary relationship among spiders.

Arachnid diversity



Echinoderms

- Echinoderms and chordates are *deuterostomes*.
- In deuterostomes, the second embryonic opening becomes the mouth and a coelom forms by outpocketing of the primitive gut making these animals *enterocoelomates*.
- A *dipleurula larva* is found among some.

Characteristics of Echinoderms

- *Echinoderms* are a diverse group of marine animals; there are no terrestrial echinoderms.
- Claim to fame is the water vascular system.
- Water enters madreporite – stone canal – ring canal – radial canal – lateral canal – podia (tube feet)
- They have an *endoskeleton* consisting of spine-bearing, calcium-rich plates.
- Echinoderms are often *radially symmetrical*, although the larva is a free-swimming filter feeder with bilateral symmetry.

Characteristics of Echinoderms

- No head or brain, few specialized sensory organs
- Locomotion by tube feet (podia)
- Digestive system complete, excretory organs absent
- Sexes separate, few hermaphroditic, fertilization external
- Respiration by dermal branchiae, tube feet, respiratory tree (cucumbers) and bursae (brittle stars)

Echinoderm Classification

- Sea lilies (class Crinoidea)
- Sea cucumbers (class Holothuroidea)
- Brittle stars (class Ophiuroidea)
- Sea urchins and sand dollars (class Echinoidea)
- Sea stars (class Asteroidea)

• Sea Stars

- *Sea stars* are an example of echinoderms and possess tiny *skin gills*, a central *nerve ring* with branches, and a *water vascular system* for locomotion.
- Water enters this system through the *sieve plate*, passes into a *ring canal*, then into *ampullae*, and into *tube feet*; expansion and contraction of tube feet move the sea star along.
- Each of the five arms contains branches from the nervous, digestive, and reproductive systems.

- When a sea star eats a bivalve, it everts its *cardiac stomach* into the bivalve and secretes enzymes; partially digested food is taken into the sea star.
- Echinoderms do not have a respiratory, circulatory, or excretory system.
- The water vascular system carries out these functions.
- Sea stars reproduce both sexually, and asexually by *fragmentation*.

Phylum Porifera

General Characteristics

- ticellular, no _____ development
- Mostly marine, all aquatic
- _____ symmetry or asymmetrical
- No organs
- Sessile (_____)
- Brightly colored
- Most are colonial, from few _____ to _____

Three types of canal systems

- _____ – **simplest - Water enters ostia, flows through spongocoel, exits osculum**
- _____ – **more complex, incurrent canals - Water enters canal, radial canal, spongocoel, then osculum**
- _____ – **most complex, flagellated chambers - Water enters ostia, flagellated chambers, excurrent pores, then osculum**

Three Basic Types of Cells

- _____ – **flat, thin, covering - Collectively called** _____
  – **"special" Porocytes perforated**
- _____ – **"collar cells" - Capture and digest food - Exposed flagella and collar of microfibrils**
  _____ – **"handyman" - Free moving**
  – **ood reserves, aid in digestion, carry pigment, form reproductive cell, or secrete skeletal material**

Three types of Skeletal Material

- _____ **spicules - May be one, three, or four rays**
- _____ **spicules - May be one, two, four, or six rays**
- _____ **- Tough, branching protein fiber, supports sponge alone or with spicules**

Lifestyles

- **All life functions depend on water current**
- _____
- **May reproduce** _____ **or** _____
  – _____ **(portion breaks off)** _____
  – _____ **(internal buds)** _____
  – _____ **form sperm and ovum** _____
- **Some** _____ **(both and male sex cells) and some** _____ **(separate sexes)**

Classification

- **Separated into classes based on skeletal type and type of canal system**

Commercial & Ecological Benefits

- Bath sponges
  _____ powers (medicine)
  Many animals live as _____ or _____ in or on sponges
- Some animals use sponges for camouflage and protection
- Provide food for some reef fishes

Phylum Cnidaria

Characteristics

- Diverse – _____ species, sea anemones, coral, hydra, jellyfish
  Mostly marine, all aquatic
- _____ symmetry – sometimes bilateral
- Two germ layers – _____
- _____ with body _____ plan
- _____ – contain stinging cells
- _____ level of organization

Cnidocytes

- Specialized cells for _____ and _____
- Contain stinging capsules called _____
- Have a _____, which when released discharges the nematocysts which harpoons or lassos
- No other organisms contain cnidocytes

Hydra

- A *hydra* polyp has an outer layer of epidermis derived from ectoderm and an inner layer called _____ derived from endoderm.
- _____lies between the two layers and contains a _____ that communicates with muscle fibers so that the animal is able to move.
- Digestion begins in a _____ and finishes in _____.
- Nutrients and gases are distributed from layer to layer by _____.

Coral Reef Paradise

Classification

- Phylum – _____ (formerly _____)
  - Corals, sea anemones, hydras, jellyfishes and their relatives
- Class – Anthozoa
- Three subclasses:
  - _____ – eight pennate tentacles – soft corals--mostly colonial
  - _____ – six pennate tentacles – hard/stony corals – black corals – solitary or colonial
  - _____ – extinct colonial corals

*Colonial corals – individual coral polyps within a colony connected by common tissue

General Information

- Deposits of calcium carbonate produced primarily by coral polyps and encrusting algae
- _____% of Earth's surface covered by coral reefs
- Found in nutrient poor areas (_____ waters)
- Of all marine environments with greatest _____
- Earliest reefs developed _____ years ago – colonies of calcareous algae

Types of Reefs

- _____ – border shorelines of continents and islands in tropical seas – S. Pacific Hawaiian Islands
  _____ – form when small islands disappear below the ocean surface – Indo-Pacific
  _____ – form when land masses sink and fringing reefs become separated from shorelines by wide channels – Caribbean and Indo-Pacific

Reef Composition

- _____ – secrete calcium carbonate skeletons
- _____ organisms – break down the coral skeletons – attack dead coral
  - sponges, worms and bivalves
- _____ – parrotfish and sea urchins

Habitat Requirements

- Warm, clear, shallow, tropical, marine water
  - _____ degree Fahrenheit isotherm
  - Light penetration for _____
    - Usually not found at depths w/light levels below 2% of the average surface sunlight
  - Salinity _____ ppt or psu

What They Do for Us (+)	VS.	What We Do for Them (-)
Provide shorelines	Pollute them	Mine them
Nurseries	Fish them in destructive ways	Smother them
Protein source	Provide jobs	Source of medicine
Study and enjoyment	Food, shelter and protection	Ground boats
Chop them for commercial	Drop anchors, step, and drag dive gear on them	

Diet

_____ (tiny drifting animals or small fishes & _____

Major Producers

- _____
  - Yellow-brown algae (_____)
  - Live symbiotically within coral - Food (photosynthesis) in exchange for shelter, protection and access to light

Other Major Producers

_____ _____

_____ _____

Methods of Eating

- _____ – detecting prey
- _____ feeders
- Tentacles move food to mouth
- Secrete _____ to collect fine organic particles
- In reef-building corals, mobile stomach filaments can capture and digest food particles
- Excretes solid wastes through mouth

Reproduction

- _____
  - _____ fertilization or _____ fertilization
  - Hermaphroditic
  - _____ spawning
  - Once settled on hard substrate, _____ develops
- _____
  - Environmental dislodging/relocation to new part of reef
  - New colonies split to form separate colonies
  - _____ – pinching off of parent polyp to form new individual

Helminthology

Phylum Platyhelminthes - _____

Phylum Nematoda - _____

Phylum Annelida – _____

Overview of flatworms

- Flatworms are characterized by the _____ level of organization and a _____ body plan.
- These _____ have three germ layers, and have all organs except respiratory and circulatory organs.
- The flat body facilitates diffusion of _____ and other molecules from cell to cell.

Flatworms

- _____ – free living carnivores
- _____ flukes – single host _____ (_____)
- _____ – mutiple hosts _____ (_____)
- _____ – vertebrate endoparasites

Planarians

- *Planarians* are _____, _____, flatworms.
- _____ function in excretion.
- The small brain extends to a _____ arrangement of nerves.
- Light-sensitive organs (_____) are in the head; planarians exhibit *cephalization.*
- One organism has both male and female sex organs – they are _____.

Parasitic Flatworms

- Flukes and tapeworms are two classes of parasitic flatworms; both have _____ hosts.
  _____ are oval to elongate and have suckers at the anterior end.
  Blood flukes cause _____; other flukes infect the digestive tract, bile duct, and lungs.
- A _____ has an anterior _____ with hooks and suckers to hold itself inside the gut.

Roundworms

- _____ have the tube-within-a-tube plan; they are prevalent in soil and some parasitize animals and plants.
- The _____ is a body cavity incompletely lined with _____.
- The fluid-filled interior forms a _____ *skeleton.*
- Most species of roundworms have _____ males and females (_____)

Phylum Annelida

- _____ – mostly marine
- Earthworms – some freshwater; some _____
- Leeches

Annelids

- _____ are segmented both externally, and internally by partitions called _____.
- Annelids have a _____, and partitioning of the coelom permits each body segment to move independently.
- The _____ body plan allows the digestive tract to have specialized organs.

Marine Worms

- _____ are marine worms with paddlelike _____ at the side of each segment.
- Some polychaetes are sessile _____.
  A _____ is a predaceous marine worm with a defined head region.
- During breeding seasons, some worms form sex organs in special segments and shed these segment during breeding.

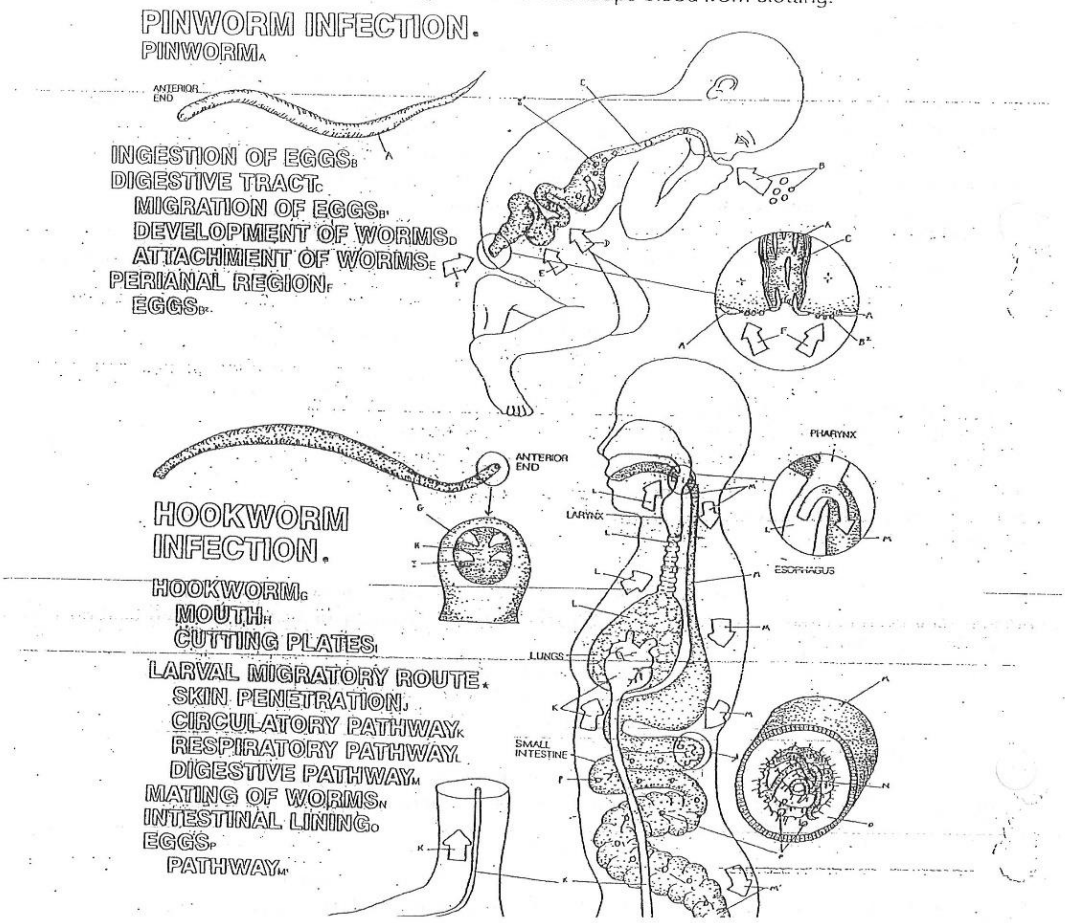
Earthworms

- *Earthworms* are _____ having few *setae* per segment.
- Most scavenge for food in the soil and the moist body wall functions in gas exchange.

- Five _____ pump blood and a branch blood vessel reaches each segm
- These worms are _____ (_____).
- Segmentation in earthworms is evidenced by: six items
  - Body rings
  - _____ divided by septa
  - _____ on most segments
  - _____ and lateral nerves in each segment
  - _____ in most segments
  - Branch blood vessels in each segment

Leeches

- Most _____ are fluid feeders that attach themselves to open wounds using suckers.
- Bloodsuckers, such as the medicinal leech, can cut through tissue.
- An anticoagulant (_____) in their saliva keeps blood from clotting.



Phylum Mollusca

Examples include snails, slugs, chitons, octopus, squid, elephant tusk shells, whelks, scallops, clams, mussels
"Claim to fame"- _____ to scrape food

Characteristics of Molluscs

mollusc body typically contains a _____, a _____, and a _____.
Molluscan groups are distinguished by a _____.
In _____, the foot is ventrally flattened.
In _____, the foot has evolved into tentacles about the head.

More Characteristics

_____ symmetry, unsegmented
- _____ mainly limited around the heart
- _____ circulatory system (_____ with cephalopods) with three chambered heart
- Gas exchange by gills, lungs, mantle, or body surface
- One or two kidneys (_____)
- Nervous system with _____ and _____ in some
- Sensory organs of touch, smell, taste, equilibrium, and vision (esp. _____)

•Class	•Examples	•Foot	•Shell
•Polyplacophora	•chiton	•Broad & flat	•8 plates
•Scaphopoda	•Elephant tusk shells	•conical	•Tubular open at both ends
•Gastropoda	•Snail slug whelks	•Large & flat	•Coiled-not or absent
•Bivalvia •Pelecypoda	•Scallops mussels	•Wedge shaped	•Two valves
•Cephalopoda	•Squid octopus nautilus	•Into a funnel	•Reduced internal or absent

Some shells in our area:

Medical Benefit of mollusks:

Arthropods

- ***Arthropods*** are the most _____ & _____ of animals
- Eucoelomate _____, _____ symmetry, _____ body
  Complex muscular system
- _____ circulatory system
- Sexes usually separate (_____)
- Three body regions – _____, _____, and _____ – with specialized appendages in each region, and a well-developed nervous system characterize this group.

Success of Arthropods

- Versatile _____
- _____ and _____ for more efficient locomotion
- _____ piped directly to cells
- Highly developed _____ organs
- Complex behavior patterns
- Reduced competition through _____

Subphylum Trilobita

- Extinct for _____ million years
- Bottom dwellers, probably scavengers
- Could roll up like pill bugs

Class Merostomata

- _____ species alive today
  Unsegmented with _____, abdomen with _____, and long _____
- Used in medicine for microbial testing

Crustaceans

- _____ are largely marine and have a head that bears _____ eyes, _____ pair of antennae, and specialized mouth parts.
- Five pairs of _____ ***legs*** include a first pair of pinching claws.
- In the crayfish, head and thorax are fused into a _____ which is covered on the top and sides by _____.
- The abdominal segments have _____.

Class Branchipoda

- Reduced first antennae
- Legs are _____, _____ and are the chief respiratory organs
- Legs may also be used in _____ and/or locomotion

Class Maxillopoda

- Basically have five cephalic, six thoracic, and four abdominal somites plus a telson

Class Malacostraca

- Largest class of _____ and greatest diversity
- Trunks has _____ thoracic and _____ abdominal somites, each with a pair of appendages
  The crayfish has an open circulatory system in which the heart pumps blood into a _____ consisting of sinuses where the _____ flows about the organs.
- Respiration takes place by gills under the hard carapace, and there is a ventral solid nerve cord. Sexes are _____ in the crayfish.

PHYLUM ARTHROPODA II

- _____ are the most varied and numerous of animals
- _____ protostomes, _____ symmetry, _____ body
- _____ muscular system
- _____ circulatory system
- Sexes usually _____
- Three body regions – _____, _____, and _____ – with specialized appendages in each region, and a well-developed nervous system characterize this group.

Success of Arthropods

- Versatile _____
- Segmentation and appendages for more efficient _____
- Air piped directly to _____
- Highly developed _____ organs
- Complex _____ patterns
- Reduced competition through _____

Class Insecta

- The head of an *insect* usually bears a pair of _____, _____ eyes, and _____ eyes.
- The thorax bears _____ pairs of legs and up to _____ pairs of wings, and the abdomen contains most of the _____ organs.
- The insect exoskeleton is lighter and contains less _____ than that of many other arthropods.
- *Grasshoppers* are examples of insects adapted to a terrestrial life; they respire by_____ and have wings that allow them to evade enemies; the third pair of legs is suitable for _____.
- There is a _____ for the reception of sound waves and a male penis for passing sperm to the female without desiccation.

_____ function in excretion in grasshopper.

- Grasshoppers undergo *gradual metamorphosis or* _____
  Egg - _____(_____) - _____
- Butterflies undergo *complete metamorphosis or* _____,
- Egg - _____ - _____ - _____.

Class Diplopoda

Includes millipedes (_____ and _____ sets of walking legs per segment)

Class Chilopoda

Includes centipedes (_____ predators with _____ set of legs per segment)

Class Arachnida

- The _____ include terrestrial spiders, scorpions, ticks, and mites.
- The _____ bears six pairs of appendages: the _____(_____) and the _____, and four pairs of walking legs.
- _____ are the oldest terrestrial arthropods.
- _____ and _____ are parasitic.
- _____ are well-adapted to life on land and have Malphigian tubules – they secrete uric acid, helping to conserve water.
- Spiders spin _____ used in various ways. (_____)
- Where spiders spin webs, the type of _____ is a feature that demonstrates the evolutionary ationship among spiders.

Echinoderms

- Echinoderms and chordates are _____.

In deuterostomes, the second embryonic opening becomes the _____ and a coelom forms by outpocketing of the primitive gut making these animals _____.

- A _____ *larva* is found among some.

Characteristics of Echinoderms

- *Echinoderms* are a diverse group of marine animals; there are no _____ echinoderms.
- Claim to fame is the _____.
- Water enters _____ – stone canal – ring canal – radial canal – lateral canal – _____ (tube feet)
- They have an _____ consisting of spine-bearing, calcium-rich plates.
- Echinoderms are often _____ *symmetrical*, although the larva is a free-swimming filter feeder with bilateral symmetry.

Characteristics of Echinoderms

- No _____ or _____, few specialized sensory organs
- Locomotion by _____ (podia)
- Digestive system _____, excretory organs _____
- Sexes _____ (_____), few hermaphroditic, fertilization _____
- Respiration by _____ (_____), tube feet, respiratory tree (cucumbers) and bursae (brittle stars)

Echinoderm Classification

- Sea lilies & feather stars (class _____)
- Sea cucumbers (class _____)
- Brittle stars (class _____)
- Sea urchins and sand dollars (class _____)
- Sea stars (class _____)

Sea stars (Class Asteroidea) Example: _____

- Sea Stars

- *Sea stars* are an example of echinoderms and possess tiny _____, a central _____ with branches, and a _____ for locomotion.
- Water enters this system through the *sieve plate*, passes into a *ring canal*, then into *ampullae* (_____), and into *tube feet*; expansion and contraction of tube feet move the sea star along.
- Each of the five arms contains branches from the _____, _____, & _____ systems.
- When a sea star eats a bivalve, it everts its _____ *stomach* into the bivalve and secretes enzymes; partially digested food is taken into the sea star.
- Echinoderms do not have a _____, _____, or _____ tem.
- The water vascular system carries out these functions.
- Sea stars reproduce both _____, and asexually by _____.

Name: Class: Date:

#1 Type of canal system is

A) asconoid
B) synconoid
C) leuconoid
D) pseudoconoid

#2 Type of cell pictured is

A) amebocyte
B) spicule
C) choanocyte
D) pinacocyte

#3 This type of structure is

A) ameboid cells
B) spicules
C) osculum
D) ostia

#4 Sponges have a central cavity called the

a) spicule
b) spongocoel
c) osculum
d) gastrovascular cavity

#5 Class Calcispongiae (Calcera) include sponges with _____ spicules.

A) silica
B) calcium carbonate
C) spongin
D) quartz

#6 Type of canal system is

A) asconoid
B) synconoid
C) leuconoid
D) pseudoconoid

#7 The four classes of sponges are separated by _____.

A) habitat
B) type of spicule
C) type of canal system
D) type of spicule and canal system

#8 Water leaves the spongocoel via the

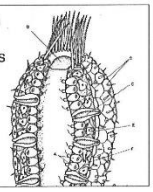
a) spicule
b) spongocoel
c) osculum
d) stomach

#9 The poorly defined tissue layers of poriferans include a(n)

a) innermost layer of collar cells
b) inner layer of elongated epidermal cells
c) layer of wandering amoeboid cells
d) both a and c

#10 Osculum is labeled as

A) A
B) B
C) C
D) D



#11 Sponges are multicellular filter-feeders that have ___ organ(s).

A) two
B) three
C) four
D) no

#12 The sponges are a "dead end" phylum because ____

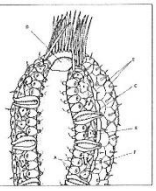
A) they are entirely made of dead cells.
B) they have not evolved much.
C) they never die.
D) both ends of the animal are packed with dead cells.

#13 ___ are needlelike crystals of calcium carbonate or siliceous material that help a sponge maintain their shape.

a) Osculums
b) Spongocoels
c) Epidermal nodules
d) Spicules

#14 Spicules are lettered as...

A) C
B) D
C) E
D) F



#15 Which of the following is related to sexual reproductin within a sponge

A) budding
B) gemmules
C) regeneration
D) archaeocyte

Porifera deliberate practice A - (ID# 82334515) - Page 1

#16 This is called

A) spicules
B) spongin
C) silica
D) calcium carbonate

#17 Class Demospongiae is unique because it contains _____types of sponges.

A) freshwater
B) siliceous
C) asconoid
D) marine

#18 Porifera is which taxon level?

A) Kingdom
B) Phylum
C) Class
D) Order

#19 Which type of cell are perforated (has holes) for the sponge?

a. pinacocyte
b. pinacoderm
c. porocyte
d. amebocyte

#20 This is composed of . .

A) calcium carbonate
B) silica
C) protein
D) none of the above

#21 Another name for the collar cell is

A) amebocytes
B) porocyte
C) pinacocyte
D) choanocyte

#22 Characteristics of sponges include all EXCEPT

a. mostly marine
b. sessile
c. tissue development
d. few mm to 2 m in size

#23 Job is . . .

A) defense
B) support
C) feeding
D) reproduction

#24 An economic benefit of sponges include

A) homes for other organisms
B) ability of regeneration
C) food for other organisms
D) clean the water around them

#25 The outside of a sponge includes all EXCEPT

A) pinacocytes
B) choanocytes
C) pinacoderm
D) porocytes

Name: Class: Date:

#1 The characteristics of sponges include all EXCEPT

a. sessile
b. radial or asymetrical
c. simple organs
d. brightly colored

#2 Types of cells found in sponges include all EXCEPT

a. chaonocyte
b. pseudocyte
c. pinacocyte
d. amebocyte

#3 Bath sponges are found in which class?

A. Class Calcarea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#4 Venus flower basket is found in which class?

A. Class Calcarea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#5 Deep, cave dwelling sponges are found in which class?

A. Class Calcarea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#6 Water will enter a sponge by

a. ostia
b. spongocoel
c. osculum
d. flagellated chambers

#7 Water leaves a sponge by

a. ostia
b. spongocoel
c. osculum
d. flagellated chambers

#8 The leuconoid canal system is unique because

a. ostia
b. spongocoel
c. osculum
d. flagellated chambers

#9 Sponges may reproduce asexually by all EXCEPT

a. budding
b. gemmules
c. archaeocytes

#10 Freshwater sponges may be found in which class?

A. Class Calcerea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#11 Calcium carbonate spicules will be found in which class?

a. Calcarea
b. Hyalospongiae
c. Demospongiae
d. Sclerospongiae

#12 Porifera is which taxon level?

a. Kingdom
b. Phylum
c. Class
d. Order

#13 Which canal system does NOT have choanocytes in the spongocoel?

a. asconoid
b. synconoid
c. leuconoid

#14 Which type of spicules may only be six-rayed?

a. calcium carbonate
b. calcite
c. silica
d. spongin

#15 Organisms that have either male or female sex organs is described as

a. monoecious
b. dioecious
c. hermaphroditic

#16 Internal buds are called

a. sperm
b. egg
c. gemmules
d. archaeocytes

#17 Amebocytes perform all functions EXCEPT

a. carry pigment
b. beat flagella
c. secrete skeletal material
d. food reserve

#18 Lifestyles of sponges includes all EXCEPT

a. parasite host
b. commensal host
c. prey
d. predator

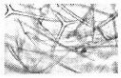
#19 Other names for calcium carbonate include all EXCEPT

a. lime
b. chalk
c. $CaCO_3$
d. siliceous

#20 What is the function of pictured?

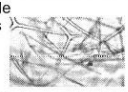
a. support
b. create current
c. secrete sex cells
d. protection

#21 What material is pictured?



A. $CaCO_3$
B. silica
C. spongin
D. quartz

#22 Which example of sponge has this type of skeletal material?



a. bath sponge
b. *Scypha*
c. *Spongilla*
d. Sponge Bob

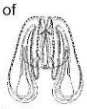
#23 Comb jellies have all of the following features EXCEPT

A) tube-within-tube body plan
B) triploblastic
C) colloblasts for capturing prey
D) rows of cilia

#24 Comb jellies belong in Phylum ___.

a. Porifera
b. Cnidaria
c. Ctenophora
d. Animalia

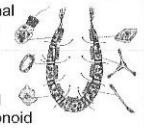
#25 Found in the Gulf of Mexico



A. moon jelly
B. cabbage head
C. comb jelly
D. Australian spotted jellyfish

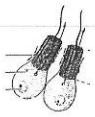
Name: Class: Date:

#1 Type of canal system is



A) asconoid
B) syconoid
C) leuconoid
D) pseudoconoid

#2 Type of cell pictured is



A) amebocyte
B) spicule
C) choanocyte
D) pinacocyte

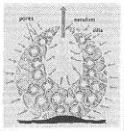
#3 These structures function

A) reproduction
B) support
C) digestion
D) excretion

#4 Sponges have a central cavity called the

a) spicule
b) spongocoel
c) stomach
d) osculum

#5 Type of canal system is



A) asconoid
B) syconoid
C) leuconoid
D) pseudoconoid

#6 How does water leave a sponge?

a) spicule
b) spongocoel
c) osculum
d) stomach

#7 The outside of a sponge includes all EXCEPT

A) pinacocytes
B) choanocytes
C) pinacoderm
D) porocytes

#8 An economic benefit of sponges include

A) homes for other organisms
B) ability of regeneration
C) food for other organisms
D) clean the water around them

#9 ___ are needlelike crystals of calcium carbonate or siliceous material that help a sponge maintain their shape.

a) osculums
b) spongocoels
c) spongin
d) spicules

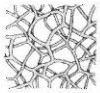
#10 Which example would be found in Class Calcera?

A) Scypha
B) Venus Flower Basket
C) bath sponges
D) cave sponges

#11 Which of the following is related to sexual reproductin within a sponge

A) budding
B) gemmules
C) regeneration
D) archaeocyte

#12 This is called



A) spicules
B) spongin
C) silica
D) calcium carbonate

#13 Which of the following is NOT a characteristic of a sponge?

A) filter feeder
B) can be up to 2m in size
C) only dull beige color
D) has no nervous or sensory systems

#14 Loose cells that wander through the gel material in the middle of the sponge are called

A) amebocytes
B) porocyte
C) pinacocyte
D) choanocyte

#15 Jobs performed by amebocytes include all EXCEPT

A) secrete spicules
B) protective covering
C) food reserves
D) reproduction

#16 Internal buds are called

a. sperm
b. egg
c. gemmules
d. archaeocytes

#17 Amebocytes perform all functions EXCEPT

a. carry pigment
b. beat flagella
c. secrete skeletal material
d. food reserve

#18 Which type of cell are perforated for the sponge?

a. pinacocyte
b. pinacoderm
c. porocyte
d. amebocyte

#19 Characteristics of sponges include all EXCEPT

a. mostly marine
b. sessile
c. tissue development
d. few mm to 2 m in size

#20 The support system of a sponge is NOT made of

A) spongin
B) silica
C) quartz
D) calcium carbonate

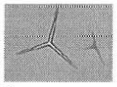
#21 Another name for the collar cell is

A) amebocytes
B) porocyte
C) pinacocyte
D) choanocyte

#22 The canal system found in very complex large sponges. It has many individual chambers filled with collar cells.

A) asconoid
B) synconoid
C) leuconoid
D) pseudoconoid

#23 This is composed of . .



A) calcium carbonate
B) silica
C) protein
D) none of the above

#24 Types of cells found in sponges include all EXCEPT

a. chaonocyte
b. pseudocyte
c. pinacocyte
d. amebocyte

#25 Deep, cave dwelling sponges are found in

A. Class Calcarea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#26 Bath sponges are found in

A. Class Calcarea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#27 Comb jellies have all of the following features EXCEPT

A) tube-within-tube body plan
B) triploblastic
C) colloblasts for capturing prey
D) rows of cilia

#28 This is composed of . .

A) calcium carbonate
B) silica
C) protein
D) none of the above

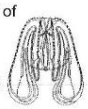
#29 Job is . . .

A) defense
B) support
C) feeding
D) reproduction

#30 Comb jellies belong in Phylum ___.

a. Porifera
b. Cnidaria
c. Ctenophora
d. Animalia

#31 Found in the Gulf of Mexico



A. moon jelly
B. cabbage head
C. comb jelly
D. Australian spotted jellyfish

#32 The outside of a sponge includes all EXCEPT

A) pinacocytes
B) choanocytes
C) pinacoderm
D) porocytes

#33 An economic benefit of sponges include

A) homes for other organisms
B) ability of regeneration
C) food for other organisms
D) clean the water around them

#34 Class Demospongiae is unique because it contains _____types of sponges.

A) freshwater
B) siliceous
C) asconoid
D) marine

#35 The sponges are a "dead end" phylum because ____

A) they are entirely made of dead cells.
B) they have not evolved much.
C) they never die.
D) both ends of the animal are packed with dead cells.

#36 Venus flower basket is found in

A. Class Calcarea
B. Class Hyalospongiae
C. Class Demospongiae
D. Class Sclerospongiae

#37 The characteristics of sponges include all EXCEPT

a. sessile
b. radial or asymetrical
c. simple organs
d. brightly colored

#38 Sponges are multicellular filter-feeders that have ___ organ(s).

A) two
B) three
C) four
D) no

#39 The BEST benefit of studying sponges is that soon may be. . .

A) cure for cancer
B) a new species discovered
C) we discover our past
D) how closely humans are related to sponges

#40 On the handout, which canal system is NOT presented?

A) asconoid
B) syconoid
C) leuconoid
D) pseudoconoid

#41 On the handout, amebocytes are related to all EXCEPT

A) C
B) F
C) E
D) all are related

#42 On the handout, the osculum is labeled

A) H
B) J
C) B
D) I

#43 On the handout, the ostia are labeled

A) J
B) H
C) B
D) N

#44 On the handout, spicules are labeled

A) J
B) E
C) F
D) H

#45 On the handout, pinacoderm is labeled

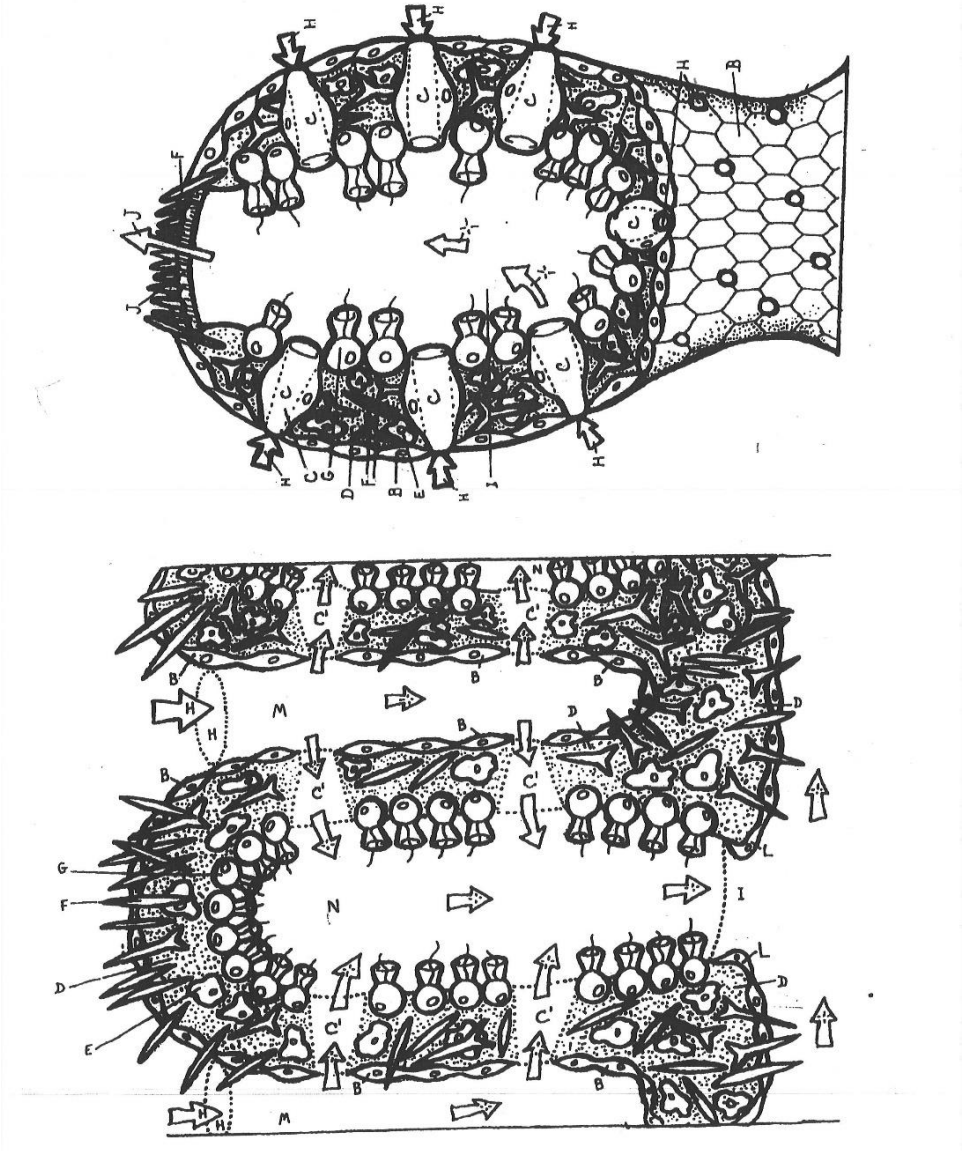
A) J
B) I
C) B
D) E

#46 On the handout, ostia is labeled

A) J
B) H
C) D
D) B

#47 On the handout, food is trapped by

A) H
B) B
C) I
D) G

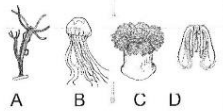


Name: Class: Date:

#1 Which is NOT a character of Phylum Cnidaria?
A. acoelomate
B. tube-within-a-tube
C. tissue organization
D. diploblastic

#2 Which is NOT a cnidarian?
a. jellyfish
b. coral
c. hydra
d. comb jelly

#3 Which is not a cnidarian?



A B C D

#4 Cnidarians have stinging cells called _____.
A. cnidocytes
B. choanocytes
C. tentacles
D. stingers

#5 The body shape of a cnidarian will be medusa form or _____ form.
A. body sac
B. tube within a tube
C. polyp
D. cylindrical

#6 Hydra are capable of asexually reproducing by.....
A. gemmules
B. budding
C. fragmenting
D. spores

#7 Cnidarians with the medusa form will have mouth that faces.....
A. upward
B. laterally
C. downward
D. dorsally

#8 Pictured is a..
A. jellyfish
B. hydra
C. comb jelly
D. Portuguese man-o-war

#9 The _____ lines the inner surface of the polyp's body.
A. ectoderm
B. epidermis
C. gastroderm
D. mesoderm

#10 Cnidarians capture prey by using stinging cells called _____ located on their tentacles.
A. cnidocytes
B. nematocysts
C. gastrodermis
D. ectoderm

#11 Which class does this belong?
A. Hydrozoa
B. Scyphozoa
C. Anthozoa
D. Cubozoa

#12 Cnidarians have _____ symmetry.
A. asymmetry
B. radial
C. lateral
D. bilateral

#13 Which polyps are the reproductive polyps of a Portuguese man o' war?
A. pneumatophore
B. gonozooid
C. dactylozooid
D. gastrozooid

#14 Cnidarians have _____ with stinging cells.
A. arms
B. limbs
C. tentacles
D. domes

#15 Jellyfish, hydra and coral are members of phylum _____.
A. Porifera
B. Cnidaria
C. Animalia
D. Ctenophora

#16 Class Hydrozoa include all members
EXCEPT

A. hydra
B. Obelia
C. sea anemone
D. Portuguese Man of War

#17 This is an example of a
A. jellyfish
B. obelia
C. hydra
D. sea anemone

#18 Jellyfish belong in Class _____.
A. Hydrozoa
B. Scyphozoa
C. Anthozoa
D. Cubozoa

#19 Which cnidarian is NOT colonial?

A. hydra
B. Portuguese man o' war
C. Obelia
D. coral

#20 Hydra may move by

A. gliding
B. "inch worm"
C. end over end
D. all of the above

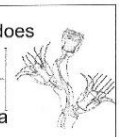
#21 The function of the pedal disc in hydra is ...

A. feeding
B. reproduction
C. stinging cells
D. base of attachment

#22 Which polyps are the "fishing" polyps of a Portuguese man o' war?
A. pneutmatophore
B. gonozooid
C. dactylozooid
D. gastrozooid

#23 Another name for hydrozoans that are colonial is .....
A. cubozoans
B. siphonophores
C. hydrozooids
D. coral

#24 Which class does this belong?



A. Hydrozoa
B. Scyphozoa
C. Anthozoa
D. Cubozoa

#25 This may be called a ___ animal.

A. "water"
B. "cup"
C. "flower"
D. "box"

Name: Class: Date:

#1 Which is NOT a character of Phylum Cnidaria?

A. acoelomate
B. body sac plan
C. tissue organization
D. triploblastic

#2 Found in the Gulf of Mexico in 2000

A. moon jelly
B. comb jelly
C. Australian spotted jellyfish
D. sea nettle

#3 Which of these you may encounter in our area that you DON'T want to sting you?

A. moon jelly
B. stinging nettle
C. cabbage head
D. comb jelly

#4 Which is NOT a cnidarian?

A. siphonophore
B. coral
C. hydra
D. comb jelly

#5 Coral belong in Class _____.

A. Hydrozoa
B. Cubozoa
C. Scyphozoa
D. Anthozoa

#6 The body shape of a cnidarian will be _____ form or polyp form.

A. body sac
B. tube within a tube
C. colonial
D. medusa

#7 Pictured is a ...

A. jellyfish
B. hydra
C. comb jelly
D. Portuguese man o' war

#8 All are native to Gulf of Mexico area EXCEPT

A. Australian spotted jellyfish
B. cabbage head
C. moon jelly
D. Portuguese man o' war

#9 Siphonophores are.....

A. colonial
B. hydrozoans
C. cnidarians
D. all of the above

#10 Jellyfish, hydra, and coral are members of Kingdom _____.

A. Porifera
B. Cnidaria
C. Animalia
D. Ctenophora

#11 Box jellyfish belong in Class _____.

A. Hydrozoa
B. Cubozoa
C. Scyphozoa
D. Anthozoa

#12 Comb jellies belong in Phylum ___.

A. Porifera
B. Cnidaria
C. Ctenophora
D. Hydrozoa

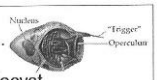
#13 The larval form of a cnidarian is called

A. zygote
B. planula
C. worm
D. maggot

#14 The "claim to fame" for Cnidarians is

A) calcium carbonate
B) nematocysts
C) body sac plan
D) tentacles

#15 Identify....



A. nematocyst
B. pedal disc
C. cnidocyte
D. gastrodermal cell

#16 Which polyps are the "fishing" polyps of a Portuguese man o' war?

A. pneutmatophore
B. gonozooid
C. dactylozooid
D. gastrozooid

#17 Cnidarian tentacles are used for all EXCEPT

A. defense
B. food gathering
C. waste removal
D. movement

#18 Method of reproduction (ex. hydra) - new organisms produced from groups of cells that enlarge & stay attached to the parent for a time before breaking off, becoming independent is called .....

A. sporulation B. binary fission
C. budding D. gemmules

#19 The free-swimming form found among cnidarians that usually looks like a rounded dome with hanging tentacles is a ...

A. medusa
B. mesoglea
C. polyp
D. planula

#20 Cnidarians have a sessile stage that is attached to the substrate, with the tentacles pointing up, called a ....

A. medusa
B. mesoglea
C. polyp
D. planula

#21 The outer layer of a cnidarian is composed of the tissue known as a

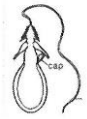
A. phisoderm
B. endoderm
C. placoderm
D. ectoderm

#22 "No medusa stage" is characteristic of which class?

A) Anthozoa
B) Cubozoa
C) Hydrozoa
D) Scyphozoa

#23 This is a picture of ...

A. hydra
B. comb jelly
C. nematocyst
D. pedal disc



#24 The freshwater form of cnidarians include ...

A) sea anemones
B) coral
C) hydra
D) jellyfish

#25 Types of jellyfish include all EXCEPT

A) cabbagehead
B) moon jelly
C) siphonophore
D) sea nettle

Name: Class: Date:

#1 The "claim to fame" for Cnidarians is ...
A) calcium carbonate
B) nematocysts
C) body sac plan
D) tentacles

#2 Comb jellies have all of the following features EXCEPT
A) sac body plan
B) tentacles
C) colloblasts
D) rows of cilia

#3 Sexual reproduction in corals include all EXCEPT
A) internal fertilization
B) external fertilization
C) synchoronus spawning
D) budding

#4 Types of jellyfish include all EXCEPT
A) cabbagehead
B) moon jelly
C) comb jelly
D) sea nettle

#5 Factors that affect growth of coral reefs include all EXCEPT
A) temperature
B) turbidity
C) depth
D) chlorophyll

#6 "No medusa stage" is a characteristic of which class?
A) Anthozoa
B) Cubozoa
C) Hydrozoa
D) Scyphozoa

#7 The body shape of a cnidarian will be medusa form or _____ form.
A. body sac
B. tube within a tube
C. polyp
D. asymmetrical

#8 Which is NOT a cnidarian?
A. hydra
B. sea anemone
C. comb jelly
D. Portuguese man o' war

#9 Which is NOT a character of Phylum Cnidaria?
A. eucoelomate
B. sac body plan
C. tissue organization
D. diploblastic

#10 All are native to Gulf of Mexico EXCEPT
A. Australian spotted jellyfish
B. cabbage head
C. moon jelly
D. Portuguese man o' war

#11 The box jellyfish is found in Class ...
A. Anthozoa
B. Cubozoa
C. Hydrozoa
D. Scyphozoa

#12 Corals may build their skeletons with all EXCEPT
A) calcium carbonate
B) protein
C) silica

#13 Types of reefs include all EXCEPT
A) atoll
B) fringing
C) scattered
D) barrier

#14 Coral have a mutualistic relationship with ...
A) plankton
B) sea anemones
C) zooxanthellae
D) bacteria

#15 Portuguese man o' war can be found in Class ...
A. Anthozoa
B. Cubozoa
C. Scyphozoa
D. Hydrozoa

#16 The freshwater form of cnidarians include ...

A) sea anemones
B) coral
C) hydra
D) jellyfish

#17 Types of reef that has a lagoon separating from open water is called ....

A) atoll
B) fringing
C) scattered
D) barrier

#18 Cnidarians capture prey by using "stinging structures" called ___ located on their tentacles.

A. cnidocytes
B. nematocysts
C. gastrodermis
D. ectodermis

#19 The name of the cell that contains this structure is called ...

A. hydra
B. cnidocytes
C. nematocyst
D. pedal disc

#20 Texas Flower Bank Gardens is which type of reef?

A) atoll
B) fringing
C) scattered
D) barrier

#21 Corals provides _____ for zooxanthellae.

A. food
B. carbon dioxide
C. oxygen
D. color

#22 Function of the bud on hydras is ...

A. feeding
B. reproduction
C. stinging cells
D. regeneration

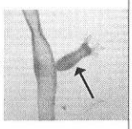
#23 Zooxanthellae provides _____ for corals.

A. food
B. carbon
C. oxygen
D. reproductive structures

#24 The inner layer of a cnidarian is composed of the tissue known as a

a) phisoderm
b) endoderm
c) placoderm
d) ectoderm

#25 Identify....



A. tentacle
B. gemmule
C. cyst
D. bud

Name: Class: Date:

#1 The "claim to fame" for Cnidarians is

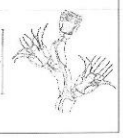
A) calcium carbonate
B) nematocysts
C) body sac plan
D) tentacles

#2 Members of Class Anthozoa include all EXCEPT

A) sea anemones
B) jellyfish
C) stony corals
D) soft corals

#3 Which class does this belong?

A) Cubozoa
B) Anthozoa
C) Scyphozoa
D) Hydrozoa



#4 Types of reefs include all EXCEPT

A) island
B) fringing
C) atoll
D) barrier

#5 Sea anemones are found in which class?

A) Anthozoa
B) Scyphozoa
C) Hydrozoa
D) Cubozoa

#6 Which organism does NOT have nematocysts to sting?

A) cabbagehead
B) moon jelly
C) comb jelly
D) sea nettle

#7 Which is not a cnidarian?

A B C D

#8 All are found in Class Hydrozoa EXCEPT

A) Portuguese Man o' War
B) hydra
C) sea anemone
D) Obelia

#9 Factors that affect growth of coral reefs include all EXCEPT

A) temperature
B) turbidity
C) depth
D) amount of calcium dissolved in water

#10 Pictured is a ...

A. jellyfish
B. hydra
C. comb jelly
D. Portuguese man o' war

#11 Box jellies are found in which class?

A) Anthozoa
B) Cubozoa
C) Hydrozoa
D) Scyphozoa

#12 Hydra are capable of asexually reproducing by.....

A. gemmules
B. budding
C. fragmenting
D. spores

#13 Siphonophores are.....

A. colonial
B. hydrozoans
C. cnidarians
D. all of the above

#14 Which polyps are the "fishing" polyps of a Portuguese man o' war?

A. pneutmatophore
B. gonozooid
C. dactylozooid
D. gastrozooid

#15 A freshwater example of cnidarians include ...

A) sea anemones
B) coral
C) hydra
D) siphonophores

#16 Pictured is a...
A. jellyfish
B. hydra
C. comb jelly
D. Portuguese man-o-war

#17 Another name for hydrozoans that are colonial is .....
A. cubozoans
B. siphonophores
C. hydrozooids
D. coral

#18 Which class does this belong?

A. Hydrozoa
B. Scyphozoa
C. Anthozoa
D. Cubozoa

#19 Types of jellyfish include all EXCEPT
A) cabbagehead
B) moon jelly
C) siphonophore
D) sea nettle

#20 This animal is in which Kingdom?
A) Cnidaria
B) Ctenophora
C) Animalia
D) Scyphozoa

#21 Class Hydrozoa include all members EXCEPT
A. hydra
B. Obelia
C. sea anemone
D. Portuguese Man of War

#22 Texas Flower Bank Gardens is which type of reef?
A) atoll
B) fringing
C) scattered
D) barrier

#23 This is a picture of ...

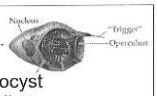
A. hydra
B. comb jelly
C. nematocyst
D. pedal disc

#24 Which organism is found in Class Anthozoa?
a. hydra
b. Portuguese man o war
c. Obelia
d. coral

#25 This may be called a ___ animal.
A. "water"
B. "cup"
C. "flower"
D. "box"

#26 Which polyps are the reproductive polyps of a Portuguese man o' war?
A. pneumatophore
B. gonozooid
C. dactylozooid
D. gastrozooid

#27 Identify....



A. nematocyst
B. pedal disc
C. cnidocyte
D. gastrodermal cell

#28 The larval form of a cnidarian is called
A. zygote
B. planula
C. worm
D. maggot

#29 This is an example of a
A. jellyfish
B. obelia
C. hydra
D. sea anemone

#30 Function of the bud in hydras ....
A. feeding
B. reproduction
C. stinging cells
D. base of attachment

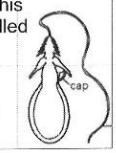
#31 Corals may build their skeletons with all EXCEPT

A) calcium carbonate
B) hydrochloric acid
C) protein

#32 Which is NOT a cnidarian?

A. comb jelly
B. coral
C. hydra
D. sea anemone

#33 The name of the cell that contains this structure is called



a. hydra
b. cnidocytes
c. nematocyst
d. pedal disc

#34 Which is NOT a character of Phylum Cnidaria?

A. true coelomate (eucoelomate)
B. body sac plan
C. tissue level of organization
D. diploblastic

#35 Coral have organisms that provide them with food called

A) plankton
B) sea anemones
C) zooxanthellae
D) bacteria

#36 Which animal is an exotic to the Gulf of Mexico?

A. Australian spotted jellyfish
B. cabbage head
C. moon jelly
D. Portuguese man o' war

#37 The inner layer of a cnidarian is composed of the tissue known as a

a) phisoderm
b) endoderm
c) placoderm
d) ectoderm

#38 Comb jellies are classified into Phylum

A) Cnidaria
B) Ctenophora
C) Animalia
D) Hydrozoa

#39 The body shape of a cnidarian will be medusa form or _____ form.

A. body sac
B. tube within a tube
C. polyp
D. triploblastic

#40 Which of these you may encounter in our area that you DON'T want to sting you?

A. moon jelly
B. stinging nettle
C. cabbage head
D. comb jelly

#41 The _____ lines the inner surface of the polyp's body.

a. ectoderm
b. epidermis
c. gastroderm
d. mesoderm

#42 STATION ONE
Which organism has rows of cilia to move?

A) A
B) B
C) C

#43 STATION ONE
Which cnidarian is colonial?

A) A
B) B
C) C

#44 STATION ONE
Which organism has both feeding and reproductive polyps?

A) A
B) B
C) C

#45 STATION TWO
Oral arms are which pin?

A) white A
B) white B
C) white C
D) white D

#46 STATION TWO
Which pin is nearest the mouth?

A) white A
B) white B
C) white C
D) white D

#47 STATION TWO
Which pin do you find special sensory structures (rhopalium)?

A) white A
B) white B
C) white C
D) white D

#48 STATION THREE
Which pin do you find the basal or pedal disc?

A) yellow A
B) yellow B
C) yellow C
D) yellow D

#49 STATION THREE
Which pin do you find the mouth?

A) yellow A
B) yellow B
C) yellow C
D) yellow D

#50 STATION THREE
Which pin do you find the nematocysts?

A) yellow A
B) yellow B
C) yellow C
D) yellow D

Name: Class: Date:

#1 Which of the following is not an example of a flatworm?
a) planarian
b) fluke
c) ringworm
d) tapeworm

#2 Which flatworm is NOT parasitic?

a) flukes
b) tapeworms
c) planarians
d) mongenetic flukes

#3 The anterior end of a tapeworm is called ...

a. proglottid
b. scolex
c. coelom
d. parapodia

#4 Platyhelminthes lack ....

A. respiratory system
B. circulatory system
C. skeletal system
D. all of the above

#5 The eyespots (ocelli) in planaria detect ....

A. images
B. color
C. light
D. all of the above

#6 Schistosomiasis is commonly caused by a ...

A. tapeworm
B. fluke
C. planaria
D. all of the above

#7 Which type of host does the parasite inhabit to grow and hopefully get to its final host?
A. definitive
B. intermediate
C. asexual
D. sexual

#8 Parasites that are ectoparasites live on the _____ of their host.

A. outside
B. inside
C. digestive tract
D. respiratory system

#9 Planarians are _____, meaning that they have both male and female structures.
a. hermaphroditic
b. dioceious
c. asexual
d. parasitic

#10 Planaria are found in Class ....

A. Turbellaria
B. Monogenea
C. Trematoda
D. Cestoda

#11 Most forms of flatworms have complex reproductive systems described as ...
A. dioecious
B. monoecious
C. incomplete
D. asexual

#12 Single host flukes are found in Class ...

A. Turbellaria
B. Monogenea
C. Trematoda
D. Cestoda

#13 Parasite that require at least two hosts, with adult commonly in digestive tracts of vertebrates is ...
A. fluke
B. planaria
C. tapeworm
D. ringworm

#14 Planaria, flukes and tapeworms are members of phylum _____.

a. Platyhelminthes
b. Nematoda
c. Annelida
d. Cnidaria

#15 In a flatworm, the body plan is described as...

A. sac body
B. tube within a tube
C. diploblastic
D. having a mouth and anus

#16 Characteristics of Phylum Platyhelminthes include all EXCEPT
A. bilateral symmetry
B. pseudocoelomate
C. body sac plan
D. simple sense organs

#17 Flame cells are part of the ___ system of planaria.

A. respiratory
B. reproductive
C. excretory
D. reproductive

#18 A tapeworm uses its _____ to attach itself to the host's intestines.
a. scolex
b. slime
c. teeth
d. it doesn't attach

#19 Hosts of tapeworms include all EXCEPT
A. humans
B. cats
C. dogs
D. cnidarians

#20 A tapeworm gets its nutrients by .....
A. diffusion
B. sucking through scolex
C. osmosis
D. chewing through intestinal wall

#21 Each section (proglottids) on a tapeworm contains _____ organs.

A. digestive
B. circulatory
C. reproductive
D. respiratory

#22 Tapeworms are found in Class ...
A. Turbellaria
B. Trematoda
C. Cestoda
D. Trematoda

#23 Worms with bodies flattened dorsoventrally, with no internal body space and incomplete digestive system are ...
a. platyhelminthes
b. nematoda
c. annelida
d. segmented worms

#24 Platyhelminths are termed ___ because they do not have a cavity between their digestive tract and body wall.
a) coelomates
b) acoelomates
c) protostomes
d) deuterostomes

#25 Which of the following is NOT a characteristic of Phylum Platyhelminthes?

A) tube within a tube body plan
B) monoecious
C) lack respiratory and circulatory organs
D) triploblastic

Name: Class: Date:

#1 Roundworms are members of the Phylum ...
A. Platyhelminthes
B. Nematoda
C. Annelida
D. Cnidaria

#2 _____ is a kind of roundworm that lives in muscle tissue.
a) Trichina
b) hookworm
c) pinworm
d) ascaris

#3 Which of the following has two body openings?
a) sponges
b) roundworms
c) flatworms
d) both b and c

#4 Phylum Nematoda includes all characteristics EXCEPT
A. cuticle covering body
B. radial symmetry
C. longitudinal muscles
D. pseudocoelomate

#5 Which worm causes Elephantiasis?
A. pinworm
B. hookworm
C. trichina worm
D. filarial worm

#6 Which worm is NOT found in our area?
a. guinea worm
b. pinworm
c. hookworm
d. trichnia worm

#7 Roundworms include all EXCEPT
a. ringworm
b. pinworm
c. hookworm
d. ascaris worm

#8 Which worm can you get by eating undercooked pork?
a. guinea worm
b. pinworm
c. hookworm
d. trichnia worm

#9 Which of these is NOT a characteristic of Phylum Nematoda?
A. hydrostatic skeleton
B. monoecious
C. tube in a tube body plan
D. cuticle covering body

#10 Worms which can be removed by winding a stick around it are called ...
a. guinea worm
b. ascasis worm
c. filarial worm
d. pinworm

#11 Another name for roundworms is ...
A. vermiform
B. nematode
C. segmented worms
D. platyhelminthes

#12 Which of these is NOT a roundworm?
A. fluke
B. pinworm
C. hookworm
D. guinea worm

#13 Parasitic roundworms that lay their eggs into their host's wastes include all EXCEPT
A. filarial worm
B. pinworm
C. hookworm
D. ascaris worm

#14 In a roundworm, the mouth and anus represent a ____ body plan.
A. sac
B. tube within a tube
C. radial
D. bilateral

#15 Which worm can you get by a mosquito bite in the tropics?
a. guinea worm
b. ascaris worm
c. filarial worm
d. pinworm

#16 Worms that can be ingested include all EXCEPT
A. pinworm
B. ascaris worm
C. trichina worm
D. filarial worm

#17 The phylum including the flukes, tapeworms, and planaria is called
a) Nematoda
b) Annelida
c) Polychaeta
d) Platyhelminthes

#18 Which of the following worms is the most common in the United States?
A) pinworms
B) hookworms
C) trichina worms
D) ascaris worms

#19 Which of the following is NOT a characteristic of Phylum Nematoda?
A) eucoelomate
B) tube within a tube body plan
C) separate sexes
D) many are parasitic

#20 Worms that can be transmitted by eating sushi include all EXCEPT
a. fluke
b. tapeworm
c. hookworm
d. roundworm

#21 Worms with bodies flattened dorsoventrally, with no internal body space and incomplete digestive system are .....
a. Platyhelminthes
b. Nematoda
c. Annelida
d. Cnidaria

#22 Which of the following is NOT a characteristic of Phylum Platyhelminthes?
A) tube within a tube body plan
B) monoecious
C) lack respiratory and circulatory organs
D) triploblastic

#23 Which worm burrows through the skin and feed on the blood of their host's intestines?
a. flukes
b. tapeworm
c. hookworm
d. pinworm

#24 What type of worm in which the eggs are ingested and female lays her eggs near the anus at night?
a. flukes
b. tapeworm
c. hookworm
d. pinworm

#25 Nematodes can be found within all areas EXCEPT
A. soil
B. water
C. organisms
D. rock

Name: Class: Date:

#1 The characteristics of Phylum Annelida include all EXCEPT
A. segmented bodies
B. true body cavity
C. complete digestive system
D. radial symmetry

#2 Which is NOT an annelid?
A. earthworm
B. leech
C. polychaete
D. tapeworm

#3 Which group of annelids is mostly marine?
A) hookworm
B) earthworm
C) polychaetes
D) leech

#4 Paddlelike appendages are called ...
A. seta
B. parapodia
C. polychaete
D. chitin

#5 The pathway of food for earthworms is as follows . . .
A. esophagus, pharynx, gizzard, intestine, crop
B. crop, gizzard, intestine, pharynx, esophagus
C. pharynx, crop, gizzard, intestine
D. pharynx, esophagus, crop, gizzard, intestine

#6 Which annelid assists in medicine?
A. leech
B. earthworm
C. polychaete
D. roundworm

#7 Which group of annelids does NOT practice cross fertilization?
A. polychaetes
B. leeches
C. earthworms
D. roundworms

#8 Leeches are classified with Class...
A. Polychaeta
B. Hirudinea
C. Oligochaeta
D. Annelida

#9 Earthworms move through soil by means of the interaction of muscles and
a) bones of an endoskeleton
b) bristlelike setae
c) appendages of an endoskeleton
d) hair-like cilia

#10 The phylum including the earthworms, polychaetes, and leeches is ...
a) Nematoda
b) Annelida
c) Polychaeta
d) Oligochaeta

#11 Earthworms maintain water and salt regulation with many kidney-like structures called the
a) nephridia
b) trachea
c) ureters
d) metanephros
e) flame cells

#12 Sandworms or tubeworms are classified with Class...
A. Polychaeta
B. Hirudinea
C. Oligochaeta
D. Annelida

#13 Which type of worm lives extreme depths and harvests chemosynthetic bacteria?
A) hookworm
B) earthworm
C) tubeworm
D) leech

#14 Which type of worm is often marine, predaceous and possess parapodia?
A) flatworm
B) oligochaete
C) roundworm
D) polychaete

#15 Earthworms absorb oxygen through their _____.
a.skin
b.mouth
c.anus
d. lungs

#16 Which is NOT a segmented worm?

A. earthworm
B. fluke
C. leech
D. sandworm

#17 Which of the following is NOT a characteristic of Phylum Annelida?

A) eucoelomate
B) tube within tube body plan
C) segmented
D) separate sexes

#18 Which annelid assists in aerating soil and providing nutrients?

A. leech
B. earthworm
C. polychaete
D. roundworm

#19 Earthworms or night crawlers are classified with Class...

A. Polychaeta
B. Hirudinea
C. Oligochaeta
D. Annelida

#20 Which of the following is NOT a characteristic of Phylum Platyhelminthes?

A) tube within a tube body plan
B) monoecious
C) lack respiratory and circulatory organs
D) triploblastic

#21 Which annelid has a fixed number of segments?

A. leech
B. earthworm
C. polychaete
D. roundworm

#22 Which of the following is NOT a characteristic of Phylum Nematoda?

A) eucoelomate
B) tube within a tube body plan
C) separate sexes
D) many are parasitic

#23 Sensory organs found in annelids include all EXCEPT

A. taste buds
B. lensed eyes
C. hearing organs
D. tactile organs

#24 Cerebral ganglia is another name for the ....

A. taste buds
B. eyes
C. setae
D. brain

#25 Which organism is NOT a worm?

A. tubeworm
B. ringworm
C. polychaete
D. roundworm

Name: Class: Date:

#1 Which of the following is not an example of a flatworm?
a) planarian
b) fluke
c) pinworm
d) tapeworm

#2 Which of the following is NOT a characteristic of Phylum Annelida?

A) eucoelomate
D) tube within tube body plan
C) segmented
D) separate sexes

#3 Which flatworm is NOT parasitic?

a) flukes
b) tapeworms
c) planarians
d) mongenetic flukes

#4 The pathway of food for earthworms is as follows . . .
A. esophagus, pharynx, gizzard, intestine, crop
B. crop, gizzard, intestine, pharynx, esophagus
C. pharynx, crop, gizzard, intestine
D. pharynx, esophagus, crop, gizzard, intestine

#5 Which of the following is NOT a characteristic of Phylum Platyhelminthes?

A) tube within a tube body plan
B) monoecious
C) lack respiratory and circulatory organs
D) triploblastic

#6 Which is not a segmented worm?

A. earthworm
B. hookworm
C. leech
D. tubeworm

#7 In a flatworm, the body plan is described as...

A. sac body
B. tube within a tube
C. diploblastic
D. having a mouth and anus

#8 Which group of annelids is mostly marine?

A) hookworm
B) earthworm
C) polychaetes
D) leech

#9 Paddlelike appendages are called ...

A. seta
B. parapodia
C. polychaete
D. chitin

#10 Which of these is NOT a characteristic of Phylum Nematoda?
A. hydrostatic skeleton
B. monoecious
C. tube in a tube body plan
D. cuticle covering body

#11 The characteristics of Phylum Annelida include all EXCEPT
A. segmented bodies
B. true body cavity
C. complete digestive system
D. radial symmetry

#12 Which of the following has two body openings?
a) sponges
b) roundworms
c) flatworms
d) both b and c

#13 Another name for roundworms is ...

A. vermiform
B. nematode
C. segmented worms
D. platyhelminthes

#14 Worms that can be ingested include all EXCEPT
A. pinworm
B. ascaris worm
C. trichina worm
D. filarial worm

#15 A tapeworm uses its _____ to attach itself to the host's intestines.
a. scolex
b. slime
c. teeth
d. it doesn't attach

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#16 Earthworms absorb oxygen through their _____.
a.skin
b.mouth
c.anus
d. lungs

#17 Flame cells are part of the ___ system of planaria.

A. respiratory
B. reproductive
C. excretory
D. reproductive

#18 Which worm is NOT found in our area?

a. guinea worm
b. pinworm
c. hookworm
d. trichnia worm

#19 Which type of worm lives extreme depths and harvests chemosynthetic bacteria?

A) hookworm
B) earthworm
C) tubeworm
D) leech

#20 Which type of host does the parasite inhabit to grow and hopefully get to its final host?
A. definitive
B. intermediate
C. asexual
D. sexual

#21 Which organism is NOT a worm?

A. tubeworm
B. ringworm
C. polychaete
D. roundworm

#22 Nematodes can be found within all areas EXCEPT

A. soil
B. water
C. organisms
D. rock

#23 Roundworms include all EXCEPT

a. ringworm
b. pinworm
c. hookworm
d. ascaris worm

#24 Which annelid assists in medicine?

A. leech
B. earthworm
C. polychaete
D. roundworm

#25 Cerebral ganglia is another name for the ....

A. taste buds
B. eyes
C. setae
D. brain

#26 Worms with bodies flattened dorsoventrally, with no internal body space and incomplete digestive system are ...
a. platyhelminthes
b. nematoda
c. annelida
d. segmented worms

#27 Platyhelminthsare termed ___ because they do not have a cavity between their digestive tract and body wall.
a) coelomates
b) acoelomates
c) protostomes
d) deuterostomes

#28 Tapeworms have a knob-like "head" structure termed the ___ bearing suckers and often hooks as well.

a) osculum
b) spicule
c) scolex
d) ganglion

#29 Which of the following worms is the most common in the United States?

A) pinworms
B) hookworms
C) trichina worms
D) ascaris worms

#30 Sensory organs found in annelids include all EXCEPT

A. taste buds
B. lensed eyes
C. hearing organs
D. tactile organs

#31 Which worm can you get by a mosquito bite in the tropics?

a. guinea worm
b. ascaris worm
c. filarial worm
d. pinworm

#32 Worms that can be transmitted by eating sushi include all EXCEPT

a. fluke
b. tapeworm
c. hookworm
d. roundworm

#33 Which of these is NOT a characteristic of Phylum Nematoda?
A. hydrostatic skeleton
B. monoecious
C. tube in a tube body plan
D. cuticle covering body

#34 The phylum including the earthworms, polychaetes, and leeches is called
a) Nematoda
b) Annelida
c) Polychaeta
d) Oligochaeta
e) Hirudinea

#35 Which of the following is NOT a characteristic of Phylum Nematoda?

A) eucoelomate
B) tube within a tube body plan
C) separate sexes
D) many are parasitic

#36 Which worm burrows into the bottom of your foot and "grazes" your intestinal lining for blood?

A) ringworm
B) hookworm
C) filarial worm
D) pinworm

#37 Hosts of tapeworms include all EXCEPT
A. humans
B. cats
C. dogs
D. cnidarians

#38 Which worm has its females lay eggs near your anus at night and cause itching?

A) hookworm
B) guinea worm
C) whipworm
D) pinworm

#39 Which type of worm is often marine, predaceous and possess parapodia?

A) flatworm
B) oligochaete
C) roundworm
D) polychaete

#40 Characteristics of Phylum Platyhelminthes include all EXCEPT
A. bilateral symmetry
B. pseudocoelomate
C. body sac plan
D. simple sense organs

#41 Platyhelminthes respire (oxygen/carbon dioxide) by

A) gills
B) lungs
C) skin
D) they do not respire, that is why they are so small

#42 *refer to handout or powerpoint* Which phylum does this specimen belong?

A) Platyhelminthes
B) Nematoda
C) Annelida
D) none of the above

#43 *refer to handout or powerpoint* Which area would you find the mouth?

A) A
B) B
C) C
D) none of the above, no mouth

#44 *refer to handout or powerpoint* Which area would you find the anus?

A) A
B) B
C) C
D) none of the above, no anus

#45 *refer to handout or powerpoint* Which letter labels the intestine?

A) A
B) B
C) C
D) D

#46 *refer to handout or powerpoint*
Which label is the uterus?

A) A
B) B
C) C
D) D

#47 *refer to handout or powerpoint*
Is this worm parasitic?

A) yes
B) no
C) only in the tropics
D) only to fish

#48 *refer to handout or powerpoint*
Which labels the crop?

A) A
B) B
C) C
D) D
E) E

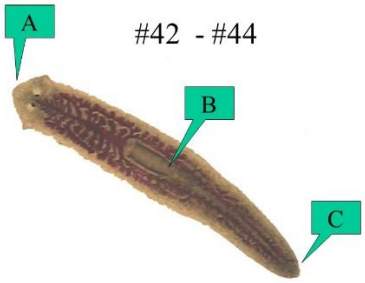
#49 *refer to handout or powerpoint*
Which label is associated with reproductive system?

A) A
B) B
C) C
D) D
E) E

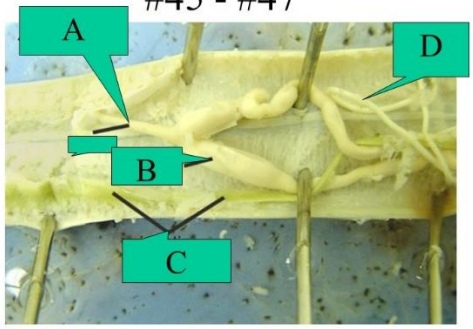
#50 *refer to handout or powerpoint*
The brain is located closest to which label?

A) A
B) B
C) C
D) D
E) E

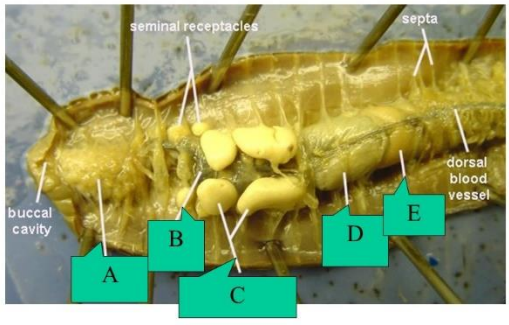
#42 - #44



#45 - #47



#48 - #50



Name: Class: Date:

#1 Which is NOT a characteristic of Phylum Mollusca?

A) triploblastic
B) segmented bodies
C) specialized sensory organs such as touch, smell, taste, vision and equilibrium
D) nervous system with brain and nerve ring

#2 Which is an example of Gastropoda?

A) snail
B) slug
C) oyster
D) both A and B

#3 The largest mollusk in the world is believed to be the

A) Giant Octopus
B) Colossal Squid
C) *Architeuthis*
D) Nautilus

#4 Which is an example of Cephalopoda?

A) squid
B) clam
C) chiton
D) slug

#5 The type of circulatory system found in most mollusks (NOT cephalopods) is

A) closed
B) impartial
C) incomplete
D) open

#6 Which is an example of Pelecypoda?

A) octopus
B) clam
C) chiton
D) snail

#7 The hard, rasping, tongue-like organ found in most mollusks is called the

A) radula
B) metanephridia
C) mantle
D) shell

#8 Which is an example of Polyplacophora?

A) squid
B) clam
C) chiton
D) slug

#9 Bivalves use ___ to bring food into their shells.

A) excurrent siphons
B) mantles
C) tentacles
D) incurrent siphons

#10 The shell of a mollusk is secreted by

A) visceral mass
B) mantle
C) gills
D) foot

#11 The "wedge-shaped" footed mollusks are in the class

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#12 Another name for Class Bivalvia is Class

A) Scaphopoda
B) Polyplacophora
C) Pelecypoda
D) Cephalopoda

#13 Most bivalves are sedentary and are therefore

A) predaceous
B) scavengers
C) decomposers
D) filter feeders

#14 The class of mollusks that are "stomach footed" are the

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#15 We classify mollusks into separate classes based on

A) locomotion
B) reproduction
C) modification of foot
D) feeding

#16 Bivalves such as oysters often secrete a substance to smooth over rough impurities inside their shell. This substance is called

A) pearl
B) crystalline
C) lamellae
D) nacre

#17 The most advanced of all the mollusks is the class

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#18 The class of "head-footed" mollusks is in the class

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#19 How many tentacles does a squid have?

A) 6
B) 8
C) 10
D) 12

#20 The shell of a mollusk is composed of

A) quartz
B) calcium carbonate
C) silica
D) sand

#21 Main means of locomotion for Pelcecypoda and Cephalopoda is

A) tentacles
B) ocean currents
C) jet propulsion
D) none of the above, sessile

#22 Siphons are utilized for

A) feeding
B) respiration
C) locomotion
D) all of the above

#23 Body regions of a mollusk include all EXCEPT

A) gills
B) mantle
C) foot
D) visceral mass

#24 "Claim to fame" for mollusks is

A) foot
B) tentacles
C) radula
D) jet propulsion

#25 You see a snail scraping algae off a rock. What tooth-like structure is it using to do this?
A. foot
B. mantle
C. visceral mass
D. radula

Name: Class: Date:

#1 Mollusks may conduct gas exchange (respire) by all EXCEPT

A) gills
B) lungs
C) anus
D) body surface

#2 The vestigial internal shell of a squid is called the

A) pen
B) style
C) mantle
D) ink gland

#3 Which is NOT a mollusk?

A) chiton
B) slug
C) nudibranch
D) planaria

#4 Some mollusks use a thick, muscular _____ for locomotion.

a. visceral mass
b. mantle
c. siphon
d. foot

#5 Which is NOT in Class Gastropoda?

A) snail
B) slug
C) elephant tusk shell
D) nudibranch

#6 Which is NOT included in Class Cephalopoda?

A) squid
B) nudibranch
C) octopus
D) chambered nautilus

#7 Bivalves use ___ to expel wastes and move water out of their shells.

A) excurrent siphons
B) mantles
C) tentacles
D) incurrent siphons

#8 Middle layer of mollusk's shell packed with calcium carbonate is called

A. Prismatic
B. Periostracum
C. Pearly
D. Nacreous layer

#9 The most advanced of all the mollusks is the class with well developed senses and capacity to learn.....

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#10 Elephant tusk shells will be classified with Class ...

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#11 Shells of cephalopods include all EXCEPT

A) two valves
B) absent
C) internal
D) external

#12 Which is NOT included in Class Bivalvia?

A) abalone
B) clam
C) oyster
D) scallop

#13 Economic/ecological impacts of mollusks include all EXCEPT

A) jewelry
B) food products
C) most are scavengers
D) bioindicator of habitat health

#14 The pen of a squid is composed of

A) calcium carbonate
B) protein
C) lipids
D) plastic

#15 Which is NOT a gastropod?

A) snail
B) slug
C) whelk
D) elephant tusk shell

#16 The foot of head-footed mollusks has been modified into _____.
A. mantle
B. tentacles
C. siphon
D. beak

#17 Which is NOT a mollusk?

a. *Coquina*
b. chambered nautilus
c. moon snail
d. shrimp

#18 Foreign objects coated with nacre are called

A. Prismatic nodes
B. Periostracum nodes
C. pearls
D. hinges

#19 Which are the three regions of mollusks?
a. head, foot, radula
b. visceral mass, radula, tentacles
c. visceral mass, foot, mantle
d. gills, mantle, visceral mass

#20 Some mollusks can even drill holes into the shells of their prey using their ...

A) radula
B) foot
C) gills
D) siphon

#21 Mollusks have a soft body which is USUALLY covered with shell is called

A. hinge
B. valve
C. foot
D. mantle

#22 Outermost layer of mollusk's shell is called

A. Prismatic
B. Periostracum
C. Pearly
D. Nacreous layer

#23 The coelom is typically reduced to just around the heart with ...

A) Scaphopods
B) Gastropods
C) Bivalves
D) Cephalopods

#24 How many chambers is the heart of mollusks?
a. one
b. two
c. three
d. four

#25 Most mollusks practice _____ reproduction.

a. asexual
b. sexual
c. hermaphroditic
d. budding

Name: Class: Date:

#1 Bivalves use ___ to close their shells

A) gills
B) retractor muscle
C) adductor muscle
D) foot

#2 Cephalopod that has an external shell is ....

A) squid
B) chambered nautilus
C) octopus
D) cuttlefish

#3 Which is NOT a bivalve?

A) clam
B) oyster
C) scallop
D) chiton

#4 The oldest part of the valve is called the ...

A. foot
B. mantle
C. peristracum
D. umbo

#5 Which is included with Class Scaphopoda?

A) snail
B) slug
C) elephant tusk shell
D) nudibranch

#6 Which cephalopod has a pen?

A) squid
B) nudibranch
C) octopus
D) chambered nautilus

#7 The anus of the clam empties into the ...

A) excurrent siphon
B) mantles
C) tentacles
D) incurrent siphon

#8 Another name for "mother of pearl" .....

A. Prismatic
B. Periostracum
C. Pearly
D. Nacreous layer

#9 The most advanced eye can be found in Class ...

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#10 Slugs, snails, nudibranchs, abalone, and whelks belong in Class ...

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#11 Cuttlefish have ___ shells.

A) two valves
B) absent
C) internal
D) external

#12 Which is NOT included in the visceral mass of a clam?

A) stomach
B) digestive gland
C) labial palps
D) gonads

#13 Ecological impacts of mollusks include ....

A) jewelry
B) food products
C) most are scavengers
D) bioindicator of habitat health

#14 Food for clams is funneled into the mouth by ...

A) adductor muscle
B) labial palps
C) foot
D) ganglia

#15 Which animal was analyzed for hydrocarbons after BP 2010 oil spill?

a. *Coquina*
b. chambered nautilus
c. moon snail
d. periwinkle

#16 Gonads of the squid is located ...
A) in the apex of the mantle
B) near the siphon
C) anterior to the mouth
D) adjacent to the gills

#17 For jet propulsion, water is drawn into the mantle by . ...
A. gills
B. tentacles
C. siphon
D. beak

#18 Which animal grazes on algae of cord grasses in our marshes?

a. *Coquina*
b. chambered nautilus
c. moon snail
d. periwinkle

#19 Part of the valve that ensures alignment so shell closes tightly is ...

A. Prismatic nodes
B. Periostracum nodes
C. umbo
D. hinges

#20 Which animal utilizes its shell for buoyancy?

a. *Coquina*
b. chambered nautilus
c. moon snail
d. periwinkle

#21 Difference between giant and colossal squid is ....

A. behavior
B. locomotion
C. hooks vs suckers on tentacles
D. the number of tentacles

#22 Which mollusk practices sequential hermaphrodism?

A) periwinkle
B) whelk
C) moon snail
D) chambered nautilus

#23 Which mollusk does NOT have a radula?

A. snail
B. clam
C. squid
D. periwinkle

#24 Outermost layer of mollusk's shell is called

A. Prismatic
B. Periostracum
C. Pearly
D. Nacreous layer

#25 Razor clams, sailor's dollars, kitten's paws, angel wings, and *Coquina*
A) Scaphopods
B) Gastropods
C) Bivalves
D) Cephalopods

Name: Class: Date:

#1 Which is NOT a characteristic of Phylum Mollusca?
A) triploblastic
B) segmented bodies
C) specialized sensory organs such as touch, smell, taste, vision and equilibrium
D) nervous system with brain and nerve ring

#2 Which specimen is NOT a mollusk?
A) chiton
B) slug
C) nudibranch
D) leech

#3 Which is NOT included with Phylum Mollusca?
A) Class Scaphopoda
B) Class Cephalopoda
C) Class Gastropoda
D) Class Amphipoda

#4 Which is NOT included with Class Gastropoda?
A) snail
B) slug
C) elephant tusk shell
D) nudibranch

#5 The largest invertebrate in the world is the
A) Giant Octopus
B) Chambered Nautilus
C) *Architeuthis*
D) Colossal Squid

#6 Mollusks may conduct gas exchange (respire) by all EXCEPT
A) gills
B) lungs
C) anus
D) mantle

#7 Which is NOT included in Class Cephalopoda?
A) squid
B) nudibranch
C) octopus
D) chambered nautilus

#8 The type of circulatory system found in most mollusks (NOT cephalopods) is
A) closed
B) impartial
C) incomplete
D) open

#9 Which is NOT included with Class Pelecypoda?
A) scallop
B) clam
C) oyster
D) chiton

#10 The hard, rasping, tongue-like organ found in most mollusks is called the
A) radula
B) metanephridia
C) mantle
D) shell

#11 Which is an example of Polyplacophora?
A) squid
B) clam
C) chiton
D) slug

#12 The oldest part of the valve is called the ...
A. foot
B. mantle
C. peristracum
D. umbo

#13 Bivalves use ___ to expel wastes and move water out of their shells.
A) excurrent siphons
B) mantles
C) tentacles
D) incurrent siphons

#14 Another name for "mother of pearl" .....
A. Prismatic
B. Periostracum
C. Pearly
D. Nacreous layer

#15 The shell of a mollusk is secreted by
A) visceral mass
B) mantle
C) gills
D) foot

#16 The hatchet (or wedge) footed mollusks are included with Class ...

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#17 Another name for Class Bivalvia is Class

A) Scaphopoda
B) Polyplacophora
C) Pelecypoda
D) Cephalopoda

#18 Most bivalves are sedentary and are therefore

A) predaceous
B) scavengers
C) decomposers
D) filter feeders

#19 Which animal utilizes its shell for buoyancy?

a. *Coquina*
b. chambered nautilus
c. moon snail
d. periwinkle

#20 Which is NOT a mollusk?

a. *Coquina*
b. chambered nautilus
c. moon snail
d. shrimp

#21 Body regions of mollusks include ...

A) mantle, foot, visceral mass
B) radula, visceral mass, foot
C) shell, visceral mass, mantle
D) tentacles, mantle, visceral mass

#22 For jet propulsion, water is drawn into the mantle by . ...

A. gills
B. tentacles
C. siphon
D. beak

#23 The Class of mollusks that are "stomach footed" are the ...

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#24 We classify mollusks based on

A) locomotion
B) location of habitat
C) modification of foot
D) size of foot

#25 Part of the valve that ensures alignment so shell closes tightly is ...

A. Prismatic nodes
B. Periostracum nodes
C. umbo
D. hinges

#26 Which mollusk does NOT have a radula?

A. snail
B. clam
C. squid
D. periwinkle

#27 Bivalves such as oysters often secrete a substance to smooth over rough impurities inside their shell. This substance is called ...

A) siphon
B) crystalline
C) lamellae
D) nacre

#28 Most mollusks practice _____ reproduction.

a. asexual
b. sexual
c. hermaphroditic
d. budding

#29 Outermost layer of mollusk's shell is called

A. Prismatic
B. Periostracum
C. Pearly
D. Nacreous layer

#30 Some mollusks can even drill holes into the shells of their prey using their ...

A) radula
B) foot
C) gills
D) siphon

#31 Food for clams is funneled into the mouth by ...

A) adductor muscle
B) labial palps
C) foot
D) ganglia

#32 The most advanced of all the mollusks is the class with well developed senses and capacity to learn.....

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#33 Foreign objects coated with nacre are called

A. Prismatic nodes
B. Periostracum nodes
C. pearls
D. hinges

#34 The class of "head-footed" mollusks are included with the Class ...

A) Scaphopoda
B) Gastropoda
C) Bivalvia
D) Cephalopoda

#35 Shells of cephalopods include all EXCEPT

A) two valves
B) absent
C) internal
D) external

#36 How many tentacles does an octopus possess?

A) 6
B) 8
C) 10
D) 12

#37 Main means of locomotion for Cephalopoda is ...

A) tentacles
B) rising and sinking by gas chamber
C) jet propulsion
D) none of the above, sessile

#38 Which is NOT a function of siphons?

A) reproduction
B) respiration
C) locomotion
D) bringing water into mantle cavity

#39 "Claim to fame" for mollusks is ...

A) foot
B) tentacles
C) radula
D) jet propulsion

#40 Which is NOT included in Class Bivalvia?

A) abalone
B) clam
C) oyster
D) scallop

#41 Ecological impacts of mollusks include all EXCEPT

A) jewelry
B) food products
C) most are scavengers
D) bioindicator of habitat health

#42 The typical external shell of a mollusk is composed primarily of ...

A) quartz
B) calcium carbonate
C) silica
D) sand

#43 Differences between Giant Squid and Colossal Squid include...

A) color
B) lifespan
C) suckers vs hooks on tentacles
D) there is NO difference, different names for same animal

#44 Which is NOT included in the visceral mass of a clam?

A) stomach
B) digestive gland
C) labial palps
D) gonads

#45 Our dissection specimen, the clam, is include with the Kingdom ...

A) Animalia
B) Mollusca
C) Eukarya
D) Invertebrata

#46 Gills are . . .

A) A
B) B
C) C
D) D

#47 Mantle is . . .

A) A
B) B
C) C
D) D

#48 Labial palps are . . .

A) A
B) B
C) C
D) D

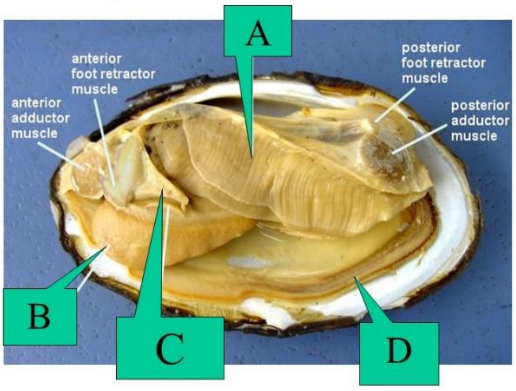
#49 Umbo is . . .

A) A
B) B
C) C
D) D

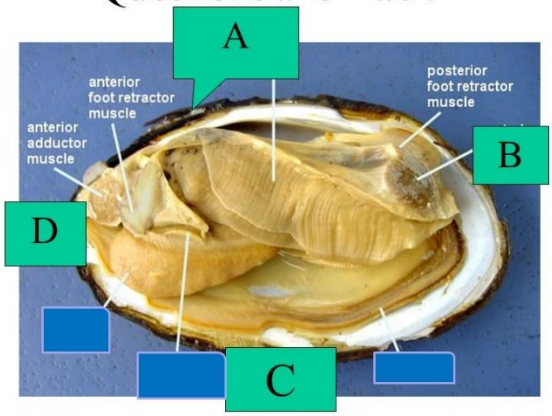
#50 Siphons are nearest to . . .

A) A
B) B
C) C
D) D

Questions #46 - #48



Questions #49 - #50



Name: Class: Date:

#1 Which of the following is NOT a characteristic of arthropods?
a) jointed legs
b) endoskeleton
c) segmented body
d) deuterostomes

#2 The _____ is a hard outer covering that is composed of a protein called chitin.

a. endoskeleton
b. exoskeleton
c. shell
d. telson

#3 Types of crustacean appendages include all EXCEPT
a. chela
b. telson
c. swimmerets
d. somites

#4 The _____ is one of the two body segments of an arthropod (head + thorax)
a) cheliped
b) mandible
c) cephalothorax
d) none of the above

#5 Horseshoe crabs are include in which Class?

a. Crustacea
b. Merostomata
c. Arthropoda
d. Chelicerata

#6 Posterior end of crustacean is called ...

A. antennae
B. carapace
C. chitin
D. telson

#7 Covering of the entire cephalothorax is called ...
a. rostrum
b. tergum
c. flexors
d. carapace

#8 Phylum Arthropoda characteristics include all EXCEPT
A. pseudocoelomate
B. complex muscular
C. open circulatory
D. metameric body

#9 Body regions of arthropods include all EXCEPT
A. head
B. waist
C. thorax
D. abdomen

#10 Success of arthropods include all EXCEPT
A. metamorphosis
B. versatile exoskeleton
C. complex behaviors
D. limited appendages

#11 Which crustacean is an example of a sessile animal?
a. barnacle
b. shrimp
c. copepod
d. crab

#12 Both shrimp and crayfish breathe by means of _____.
a. lungs
b.gills
c. swimmerets
d. exoskeleton

#13 A marsh crab has two chelipeds of different sizes. What is the larger one used for?
a.defense
b.food
c.breathing
d.locomotion

#14 A lobster has _____ pairs of legs on its cephalothorax.
a. 3
b. 4
c. 5
d. 6

#15 Copepods and barnacles are included with Class ...
a. Branchipoda
b. Maxillopoda
c. Malacostraca
d. Crustacea

#16 Lobsters, shrimp, crabs, and crayfish are all ...

a. insects
b. decapods
c. maxillopods
d. trilobites

#17 Descriptions of crustacean appendages include all EXCEPT

A. biramous
B. jointed
C. uniform
D. chitonous

#18 Lobsters, shrimp and crabs are included with Class ...

A. Malacostraca
B. Crustacea
C. Maxillopoda
D. Branchipoda

#19 Horseshoe crabs are include with Subphylum ...

a. Arthropoda
b. Chelicerata
c. Crustacea
d. Merostoma

#20 Which arthropod is extinct?

A) horseshoe crabs
B) water fleas
C) copepods
D) trilobites

#21 Which is NOT a crustacean?

A) horseshoe crab
B) shrimp
C) crab
D) barnacle

#22 Sexual dimorphism in crayfish is exhibited by the ...

Ä) swimmerets
B) chela
C) overall size of organism
D) color

#23 Deep sea isopod and wharf roaches are classified with Class ...

A) Crustacea
B) Malacostraca
C) Branchipoda
D) Maxillopoda

#24 Which arthropod assists with microbial testing of medical products?

A) spiders
B) horseshoe crabs
C) spider crab
D) trilobites

#25 Species of shrimp found in the Mississippi Sound include all EXCEPT

A) pink
B) white
C) brown
D) red

Name: Class: Date:

#1 Most of the internal organs will be found in the _____ region of an insect's body.
A) cephalothorax
B) head
C) thorax
D) abdomen

#2 Centipedes are classified within Class ...
A) Insecta
B) Diplopoda
C) Myriapoda
D) Chilopoda

#3 "True bugs" are classified within Order ...
A) Diptera
B) Hymenoptera
C) Hemiptera
D) Odonata

#4 Dragonflies, beetles, flies and grasshoppers are all classified within Class ...
A) Diplopoda
B) Chilopoda
C) Hexapoda
D) Arachnida

#5 Characteristics of Phylum Arthropoda include all EXCEPT
A) pseudocoelomate
B) bilateral symmetry
C) open circulatory system
D) three body regions

#6 Walking legs and wings, if present, will be attached to the _____ region of an insect.
A) head
B) thorax
C) cephalothorax
D) abdomen

#7 Reception of sound waves is received by _____ of an insect's body.
A) tracheae
B) spiracles
C) wings
D) tympanum

#8 Metamorphosis stages that include egg, nymph or juvenile and adult is called
A) holometabolous
B) heterometabolous
C) hemimetabolous
D) homometabolous

#9 Characteristics of Phylum Arthropoda include all EXCEPT
A) sexes usually separate
B) metameric body
C) protostomes
D) simple muscular system

#10 The head of an insect includes all EXCEPT
A) pair of atennae
B) chelicerae
C) compound eyes
D) simple eyes

#11 An insect's respiratory system includes all EXCEPT
A) malpighian tubules
B) spiracles
C) air sacs
D) tracheae

#12 Apterous insects lack ...
A) mouthparts
B) legs
C) wings
D) larvae stage of development

#13 The insects that may beat their wings independently are classified within Order ...
A) Diptera
B) Coleoptera
C) Hymenoptera
D) Odonata

#14 Elytra are classified within Order ...
A) Odonata
B) Coleoptera
C) Diptera
D) Hymenoptera

#15 Grasshoppers and crickets are classified within Order ...
A) Coleoptera
B) Orthoptera
C) Odonata
D) Lepidoptera

#16 Differences between moths and butterflies include ...
A) shape of antennae
B) size of body
C) habitat location
D) color

#17 Insects are classified within ...
A) Subphylum Crustacea
B) Subphylum Chelicerata
C) Subphylum Uniramia
D) Subphylum Trilobita

#18 The pronotum is found on the ___ region of an insect.
A) head
B) thorax
C) cephalothorax
D) abdomen

#19 "True flies" are classified within Order ...
A) Lepidoptera
B) Odonata
C) Diptera
D) Orthoptera

#20 Insects with modified ovipositors for sawing, piercing or stinging are classified within Order ...
A) Insecta
B) Hemiptera
C) Orthoptera
D) Hymenoptera

#21 Largest order of insects are classified within Order ...
A) Coleoptera
B) Lepidoptera
C) Hemiptera
D) Odonata

#22 Class Hexapoda include all EXCEPT
A) beetles
B) butterflies
C) dragonflies
D) millipedes

#23 Carnivorous predators with one set of legs per segment are called ...
A) millipedes
B) centipedes
C) arachnids
D) insects

#24 Simple eyes are also called ...
A) typanum
B) ocelli
C) spiracles
D) chrysalis

#25 Which are NOT classified within Order Hymenoptera?
A) flies
B) ants
C) wasps
D) bees

Name: Class: Date:

#1 Characteristics of Phylum Arthropoda include all EXCEPT
A) eucoelomate
B) bilateral symmetry
C) closed circulatory system
D) three body regions

#2 Which is NOT an arachnid?
A) flea
B) tick
C) mite
D) scorpion

#3 Spiders are classified within Phylum ...
A) Arachnida
B) Chelicerata
C) Arthropoda
D) Animalia

#4 Ticks, mites, spiders and scorpions are classified within Class _____.
A) Arachnida
B) Insecta
C) Chilopoda
D) Diplopoda

#5 Spiders, scorpions and ticks are classified within Subphylum _____.
A) Arachnida
B) Arthropoda
C) Chelicerata
D) Uniramia

#6 Arachnids are typically found within ___ habitats.
A) marine
B) freshwater
C) terrestrial
D) coastal

#7 Type of spider that secretes hemotoxin in our area is the ___.
A) banana spider
B) black widow
C) brown recluse
D) wolf spider

#8 "True bugs" are classified within Order ...
A) Diptera
B) Hymenoptera
C) Hemiptera
D) Odonata

#9 Which organism is a carnivorous predator?
A) millipede
B) centipede
C) grasshopper
D) lovebugs

#10 The oldest terrestrial arthropods include the ....
A) spiders
B) ticks
C) mites
D) scorpions

#11 The appendages that possess the fangs in arachnids are called ...
A) pedipalps
B) chelicerae
C) walking legs
D) spinnerets

#12 Centipedes are classified within Class ...
A) Insecta
B) Diplopoda
C) Chilopoda
D) Arachnida

#13 The appendages adjacent to the fangs with arachnids are called the ...
A) walking legs
B) spinnerets
C) pedipalps
D) mandibles

#14 Type of spider that has an hourglass shape on the female's abdomen is called ...
A) black widow
B) brown recluse
C) banana spider
D) tarantula

#15 Evolutionary relationships are demonstrated by the _____ of spiders.
A) size
B) habitat location
C) color
D) type of web formation

#16 Arachnids typically respire by ....

A) gills
B) lungs
C) book gills
D) book lungs

#17 Largest group of insects are classified within Order ...

A) Coleoptera
B) Lepidoptera
C) Hemiptera
D) Odonata

#18 Type of spider that secretes a neurotoxin in our area is called the ....

A) garden spider
B) brown recluse
C) black widow
D) banana spider

#19 Arachnids have ____ pairs of walking legs.

A) 3
B) 4
C) 5
D) 6

#20 "True flies" are classified within Order ...

A) Lepidoptera
B) Odonata
C) Diptera
D) Orthoptera

#21 Ticks in our area are responsible for ...

A) Rocky Mountain Spotted Fever
B) Malaria
C) Lyme Disease
D) A and C

#22 Insects are classified within ...

A) Subphylum Crustacea
B) Subphylum Chelicerata
C) Subphylum Uniramia
D) Subphylum Trilobita

#23 Which appendage of a scorpion is modified into the chela (claw)?

A) pedipalps
B) book lungs
C) chelicerae
D) walking legs

#24 Type of spider that is commonly called the fiddleback is the ...

A) brown recluse
B) banana spider
C) tarantula
D) black widow

#25 Which organ is responsible for assisting spiders with conserving water?

A) spinnerets
B) Malpighian tubules
C) book lungs
D) chelicerae

Name: Class: Date:

#1 Another name for skin gills or papulae is ...

a. water vascular system
b. dermal branchiae
c. pedicellariae
d. ampulla

#2 Seastars posses a system of internal tubes called ..

a. dermal branchiae
b. ampullae
c. water vascular system
d. pedicellariae

#3 This example is classified within Class ....

A. Crinoidea
B. Echinoidea
C. Ophuiroidea
D. Holothuroidea

#4 Portion of water vascular system between stone canal and radial canal is ....
a. madreporite
b. lateral canal
c. ring canal
d. ampullae

#5 Another name for shell of echinoderms is ...
a. ampullae
b. test
c. water vascular system
d. pedicellariae

#6 If a seastar loses one of its rays, it has the ability to grow it back, called ...

a. fragmentation
b. asexual reproduction
c. regeneration
d. reproduction

#7 Echinoderms utilize ___ for locomotion and food gathering.

a. test
b. ampullae
c. dermal branchiae
d. water vascular system

#8 Sea biscuits are classified within Class..

A. Crinoidea
B. Echinoidea
C. Holothuroidea
D. Ophuiroidea

#9 Class Echinoidea includes ...

a. sea urchins
b. feather stars
c. sea stars
d. sea cucumbers

#10 Seastars, urchins, and feather stars are classified within Phylum ....
a. Animalia
b. Echinodermata
c. Asteroidea
d. Echinoidea

#11 Differences among regular and irregular urchins include all EXCEPT ...
A. length of spines
B. shape of test
C. classified within different class
D. habitat

#12 Pincher-like appendages that remove debris on body and protect skin gills are called ....
a. dermal branchiae
b. water vascular system
c. pedicellariae
d. test

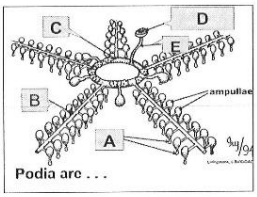
#13 Which is classified within Class Asteroidea?
a. sea urchins
b. feather stars
c. sea stars
d. sea cucumbers

#14 Urchins that posses hemispherical shape, radial symmetry, & medium to long spines are described as ...
A. regular C. irregular
B. circular D. extinct

#15 The term, Echinoderm, may be defined as...

a. slimy skin
b. bumpy skin
c. spiny skin
d. no skin

#16 Portion of water vascular system between radial canal & ampullae is .....
a. ring canal
b. lateral canal
c. madreporite
d. stone canal

#17 

Podia are . . .

#18 The feather star is classified within Class ...

A. Crinoidea
B. Echinoidea
C. Holothuroidea
D. Ophuiroidea

#19 Sea cucumbers are classified within Class ...

A. Crinoidea
B. Echinoidea
C. Holothuroidea
D. Ophuiroidea

#20 Type of symmetry for sea stars, urchins, sea cucumbers and sea lillies may be described as...
a. bilateral
b. radial
c. biradial
d. asymmetrical

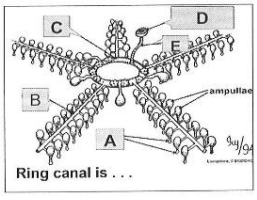
#21 The nerve ring with extensions into each arm is responsible for _____ in a seastar.
A. movement
B. coordination
C. learning
D. respiration

#22 Echinoderms are separated into Classes based on ...
a. number of spines
b. location of madreporite
c. arrangement of rays
d. presence of water vascular system

#23 Characteristics of Echinoderms include all EXCEPT
a. distinct head
b. complete digestive system
c. regeneration
d. separate sexes

#24 Members within Class Crinodea includes ....

a. sea urchins
b. feather stars
c. sea stars
d. sea cucumbers

#25 

Ring canal is . . .

APPENDIX M – Teacher Lesson Plan, Subject Zoology II, 2nd Nine Weeks

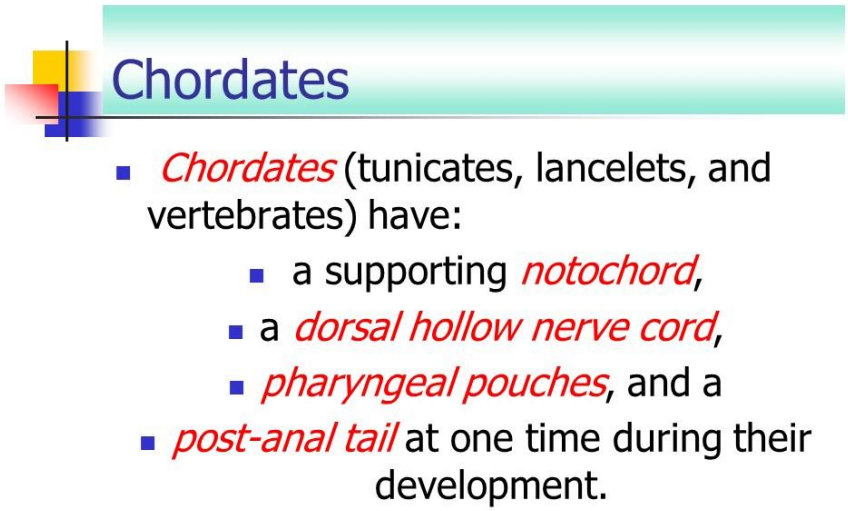
10/15-10/19/2018	Activities	Resources
ZOO.7 Students will understand the structure and function **of phylum Chordata, classes Chondrichthyes** and Osteichthyes, and how they demonstrate the characteristics of living things.	**M** – Agnatha PPT, Agnatha practice(Q), shark dichot key **T** – Chond PPT, Ultimate Shark video **W** – Chond PPT, Chond A(Q), Ultimate Shark video **TH** – Shark dissection **F** – Eyewitness:Shark, Chond B(Q)	Agnath PPT & student notes, Chond PPT & student notes, Chond A, Chond B
10/22-10/26/2018	Activities	Resources
ZOO.7 Students will understand the structure and function of **phylum Chordata, classes Chondrichthyes** and **Osteichthyes**, and how they demonstrate the characteristics of living things.	**M** – Review for test **T** – CHORDATE/CHOND TEST (Q) **W** – Osteich PPT, Osteich A(Q), fish packet **TH** – perch dissection **F** – Gulf Sturgeon video, Osteich B(Q), Eyewitness:Fish	Chordate/Chondrichthyes Test, Osteich PPT & student notes, Osteich A, Osteich B
10/29-11/2/2018	Activities	Resources
ZOO.7 Students will understand the structure and function of phylum Chordata, classes Chondrichthyes and **Osteichthyes**, and how they demonstrate the characteristics of living things.ZOO.8 Students will understand the structure and function of phylum Chordata, classes **Amphibia** and Reptilia, and how they demonstrate the characteristics of living things.	**M** – Life:Fish, bony fish dichot key **T** – review for Osteich test **W** – OSTEICHTHYES TEST (Q) **TH** – Amphi PPT, Amphi A(Q), Almighty Amphi, Salamander dichot key **F** – Amphi PPT, Amphi B(Q), Almighty Amphi	Osteichthyes Test, Amphia PPT & student notes, Amphia A, Amphia B

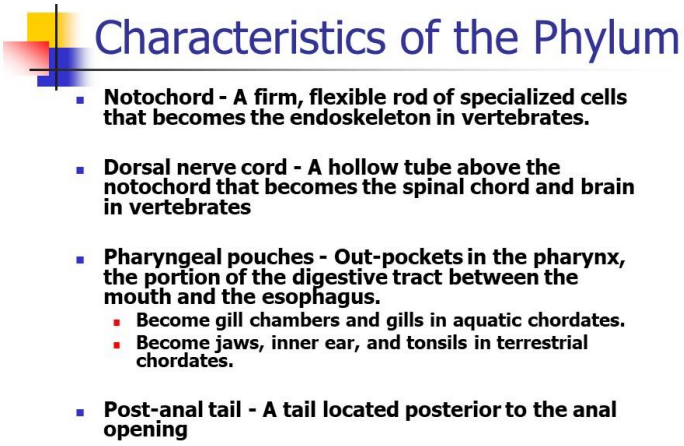
11/5-11/9/2018	Activities	Resources
ZOO.8 Students will understand the structure and function of phylum Chordata, classes **Amphibia** and **Reptilia**, and how they demonstrate the characteristics of living things.	**M** – frog dissection **T** – Almighty Amphi, Eyewitness:Amphibia, review for Amphibia test **W** – Eyewitness:Amphibia, mudpuppy dissection **TH** – AMPHIBIA TEST (Q) **F** – Reptile PPT, Reptile A(Q), serpent video	Amphibia Test, Reptile PPT & student notes, Reptile A,
11/12-11/16/2018	Activities	Resources
ZOO.8 Students will understand the structure and function of phylum Chordata, classes Amphibia and **Reptilia**, and how they demonstrate the characteristics of living things.	**M** – Reptile PPT, Reptile B(Q), serpent video **T** – turtle dissection **W** – serpent video, snake dissection **TH** – Eyewitness:Reptile, review for Reptile Test **F** – REPTILE TEST, Life:Reptiles & Amphibians	Reptile PPT & student notes, Reptile B, Reptile Test
11/26-11/30/2018	Activities	Resources
ZOO.9 Students will understand the structure and function of phylum Chordata, class Aves, and how they demonstrate the characteristics of living things.	**M** – Aves PPT, Aves A(Q), egg video **T** – Aves PPT, Aves B(Q), egg video **W** – egg video, egg lab, Eyewitness:birds **TH** – pigeon lab, egg lab, March of the Penguins **F** – March of the Penguins	Aves PPT & student notes, Aves A, Aves B
12/3-12/7/2018	Activities	Resources
ZOO.9 & ZOO.10 Students will understand the structure and function of phylum Chordata, class Aves, class Mammalia, and how they demonstrate the characteristics of living things.	**M** – bird video, review for Aves test **T** – AVES TEST (Q) **W** – Mammal PPT, Mammal A(Q) **TH** – Mammal PPT, Mammal B(Q) **F** – The Cove	Aves Test, Mammal PPT & student notes, Mammal A, Mammal B

12/10-12/14/2018	Activities	Resources
ZOO.10 Students will understand the structure and function of phylum Chordata, class Mammalia, and how they demonstrate the characteristics of living things.	**M** – Manatee PPT, manatee video **T** – rat dissection **W** – deer video, how to age a deer, calculate a pop **TH** – Life:Primates, Jane Goodall TED talk **F** – Blackfish	

APPENDIX N Teacher Powerpoint presentations for Zoology II

Teacher powerpoints have been modified to exclude supplemental pictures and video clips (Mississippi Deparment of Education, 2017; Hickman & Roberts, 1974).





4 Subphyla

- Hemichordata – acorn worms/pterobranchs
- Urochordata - tunicates
- Cephalochordata - lancelets
- Vertebrata - vertebrates

Subphylum Hemichordata

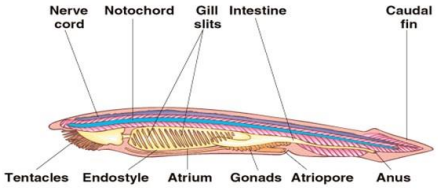
- Controversial group hemi (part), some zoologists believe they are more closely related to echinoderms due to similarities in larval forms
- a few hundred species within total group
- Include Acorn worms and pterobranchs (tiny colonial animals)
  - Some of these worms may be very large; one species may reach a length of 2.5 meters (almost eight feet), although most are much smaller.
  - **fragile tube worms that live in sand or mud burrows in the intertidal areas**
  - **body of acorn worms consists of proboscis, collar, and trunk. The proboscis is a digging organ and together with the collar (and a lot of imagination) it resembles an acorn, hence its name**
- Include pterobranchs (tiny colonial animals)
  - Only about 20 living species of pterobranchs

Invertebrate Chordates

- Lancelets and tunicates are the invertebrate chordates.
- *Lancelets* are small animals found in shallow water along the coasts; they filter feed on microscopic organisms.
- *Tunicates* (sea squirts) live on the ocean floor and filter water entering the animal through an *incurrent siphon*.
- Adult tunicates lack chordate characteristics except gill slits, but adult lancelets retain the four chordate characteristics.

Subphylum Cephalochordata

- About 24 species of Lanceletes
  - 4 in North America
- Originally named Amphioxus (sharp at both ends)
- Separate Sexes



Subphylum Urochordata

- About 2,000 species of Tunicates
- Covered by a tough covering, or tunic
- 3 classes
  - Ascidiacea
    - Most common
    - Includes sea squirts
    - Sessile
  - Larvacea
    - Builds transparent mucosal houses
  - Thaliace
    - Mobile-jet propulsion
- Tadpole larvae has all 4 hallmarks of chordates, adults have but one.
- **Water travels in the Incurrent Siphon through the pharynx (Pharyngeal slits) that leads to the stomach, food travels through the intestine to the anus and out the excurrent siphon**
- **Stolons act as holdfasts (sessile)**
- **Hermaphroditic**
- **Heart (beating one way then the other)**

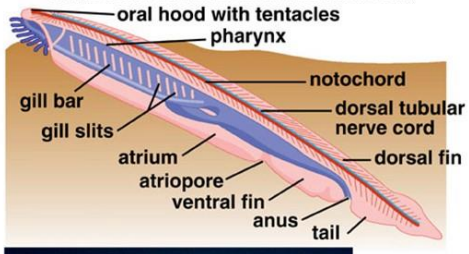
Characteristics

- Integumentary system – scales, hair, skin, feathers, sweat glands
- Muscular system – muscle is attached to bone, used for locomotion and also aids in other systems.
- Skeletal system – made up of bone or cartilage. Basic two part division – axial or appendicular (pelvic or pectoral)
- Digestive system – special features differ for each class
- Respiratory system – gills or lungs or both
- Circulatory system – closed system, heart, vessels with arteries/veins
- Excretory system – certain organ function to remove wastes
- Endocrine system – hormonal production and secretion
- Nervous system – Cephalization, development of highly specialized sensory structures and a highly specialized brain
- Reproductive system – separate organs for reproduction
  - External (fish or amphibian or Internal (reptile or bird or mammal)

Evolution of Chordates

- The lancelets and tunicates are *invertebrate chordates*.
- *Vertebrates* include the fishes, amphibians, reptiles, birds, and mammals.
- Cartilaginous fishes were the first to have *jaws*; amphibians evolved *legs* and invaded land.
- Reptiles, birds, and mammals have means of reproduction suitable to land.

Habitat and anatomy of a lancelet, *Brachiostoma*



Subphylum Vertebrata

Class	Main Characteristics	Examples
Agnatha	jawless, cartilage skeleton,gill slits, no swim bladder	Lamprey and Hagfish
Chondrichthyes	Placoid scales, cartilage skeleton internal fertilization, paired fins,	Sharks, Rays, and Skates
Osteichthyes	Bony skeleton, paired fins, operculum, swim bladder	Tuna, Bass, Catfish, Flounder
Amphibia	Smooth skin, no claws, aquatic larvae, breathe through lungs and skin	Frog, Salamander, and Toad
Reptilia	Amniote egg, rough,dry skin, respiration through lungs	Snakes, Lizards, Turtles, and crocodiles
Aves	Feathers, amniote egg, extensive lung system, and wings	Birds
Mammalia	Hair, diaphragm, mammary glands, and bear live offspring.	Marsupials, monotremes, and Placentals

Vertebrates

- At some time during their lives, all *vertebrates* have the four chordate characteristics.
- The notochord is replaced by the *vertebral column*; this *endoskeleton* demonstrates segmentation.
- The internal organs are well developed and *cephalization* places complex sense organs at the head.

- Vertebrates are distinguished in particular by these features:
  - *Living endoskeleton*
  - *Closed circulatory system*
  - *Paired appendages*
  - *Efficient respiration and excretion*
  - *High degree of cephalization*
- The evolution of jaws allowed some vertebrates to take up the predatory way of life.

Agnatha

- 84 species
- 2 classes
  - Myxini(hagfishes)
  - Cephhalaspidomorphi(lampreys)
- Separated due to morphological differences

Class Myxini: Hagfishes

- Marine – osmotic equilibrium
- Feed on annelids, mollusks, crustaceans, and dead or dying fishes
- **Not** parasitic – scavengers and predators
- Almost blind – good smell and touch senses
- Either enters an orifice or digs inside of dead fish
- Ties a knot in its tail for extra leverage
- No larval stage
- Secretes a mucosal covering
- Female outnumber the males 100 to 1
- Produce yolky eggs
- Some hermaphroditic species

Class Cephalaspidomorphi: Lampreys

- About 22 species in North America
- Some are parasitic (feeding) others are non-feeders
- Marine or Freshwater
- But are stream spawners

Lamprey's Reproduction

- Male builds a nest and is later joined by the female
- Female attaches to a rock with her mouth. The male attaches to the side of her head.
- External Fertilization occurs
- Sticky eggs stick to the nest and are covered by sand
- Adults die soon after spawning
- Eggs hatch – ammocoete larvae
- Leaves rock nest and burrows in a sandy low-current area
- 3 to 7 or more years underground
- Parasitic lampreys use their teeth to hold onto a fish and rasp at the flesh to suck out the fluids
- Anticoagulant

Great Scott!!
The Great Lakes are Invaded

- In 1829 the Welland Ship Canal was built
- Prior to this and 100 years after this, no lampreys were seen in Lake Erie
- By mid 1940's the sea lamprey was causing extraordinary damage to all the Great Lakes
- Lampreys preferred lake trout, a multimillion dollar industry
- It was brought to a total collapse by 1950's
- Then attacked yellow perch, whitefish, rainbow trout, and lake herring – all important industry fish
- Numbers began to decrease in the late 1950's and early 1960's – partly due to depletion of food supply and also human control methods (chemical larvicide)
- Experimenting with sterile males

Fishes

- Ichthology – study of fish
- Today there are three living classes of fishes: jawless fishes, cartilaginous fishes, and bony fishes – the last two groups have jaws.

• Jawless Fishes

- The first vertebrates were *jawless fishes*, today represented by hagfishes and lampreys with no scales or paired fins.
- Water moves in and out through gill openings.

Sea lamprey

Exotic species entered by way of the Welland Canal to Great Lakes region and wreck havoc on trout industry

Sea lampreys dangling from an adult lake trout.

View Larger Version

• Cartilaginous Fishes

- The *cartilaginous fishes* include the sharks, rays and skates which have skeletons made of cartilage.
- *Skates* and *rays* are flat fishes that live partly buried in the sand and feed on mussels and clams.
- *Sharks* and rays have a sense of electric currents in water, a *lateral line system*, and a keen sense of smell; these attributes help detect prey.

Skates vs. Rays

Skates – triangular, always lay eggs (mermaid's purses)

Rays – more rounded, barbed






• Bony Fishes

- *Bony fishes* have jaws and two pairs of fins and are the most diverse and numerous of all vertebrates.
- Bony fishes include those that are *ray-finned* (most abundant) and a few that are *lobe-finned*; some of the lobed-finned fishes have lungs and likely gave rise to amphibians.
- A *swim bladder* may provide buoyancy in ray-finned fishes.

- Most fishes today are ray-finned and have these characteristics:
  - *Bony skeleton and scales*
  - *Swim bladder*
  - *Two-chambered heart (one atrium, one ventricle)*
  - *Paired fins*
  - *Jaws*
  - *Gills*

Class Characteristics

- About 850 extant species
- Completely boneless class
- Odd because Chondrichthyes are derived from ancestors having well-developed bone
- Almost all are marine
- 28 species live primarily in fresh water

Subclasses

- Subclass Elasmobranchii
  - Sharks
  - Skates
  - Rays
- Subclass Holocephali
  - Chimaeras

Subclass Elasmobranchii

- About 815 species
- Nine living orders
  - Order Carcharhiniformes
    - Bull Sharks and Tiger Sharks and Hammerheads
  - Order Lamniformes
    - Great White and Mako
  - Order Squaliformes
    - Dogfish (dissection)
  - Order Rajiformes
    - Skates and Rays

Shark Attacks

- By nature, sharks are timid and cautious
- Most shark attacks are human induced (stupidity factor)
- Australia's Temperate and Tropical waters have the most shark attacks recorded
- WWII ships that sank created mass shark attacks
- Myth busters – larger gets "left alone"

Form and Function:

Characteristics of Sharks

A. Pointed mouth – rostrum
B. Fins
    a. Paired pectoral
    b. Paired pelvic – Modified for copulation in some male species (claspers)
    c. One or Two dorsal – each with a spine in *Squalus*
    d. One Caudal
C. Paired Nostrils
D. Lateral lidless eyes – nictitating eyelids in certain species
E. 5 gills slits anterior to the pectoral fin
F. Placoid scales – reduces turbulence – creates a tough leather like dermal layer

Sharks Save Energy

- Cartilage is lighter than bone. (less E to maintain bouyancy)
- Sharks' fins sit at angles which provides lift.
- Skin: denticles trap a film of water close to the shark's body. Reduces friction.
- "Conveyer belt" system for teeth.
- Senses

Ecology of Sharks

- Predators
- Highly adapted to a predatory life
  - Track their prey using highly sensitive senses in an orderly sequence
  - Detect from a kilometer or more away with their large olfactory organs – 1pptb
  - Mechnoreceptors in their lateral line system to detect vibrations
  - Vision is used at closer range (primary)

“The Sixth Sense…”

- Electroreception: Sharks can sense the minute electricity created by muscles and nerves.
- Ampullae of Lorenzini (pits near snout) detect the electric currents.
- Rays use this sense to fin prey hiding under the sand.

Digestion

- Upper and Lower jaws have many sharp triangular teeth (rows)
- Mouth cavity opens into a large pharynx (contains opening to the gill slits - respiration)
- Short, wide esophagus runs to a J-shaped stomach
- The liver and pancreas open into the short, straight intestine which contains the spiral valve (slows down food to increase absorption)
- Short rectum that leads to the rectal gland(unique to chondrichthyes – secrets a colorless fluid containing a high concentration of NaCl – assist kidney in NaCl regulation in the the blood)

Circulatory

- Two chambered heart
- Closed circulatory system
- Typical of gilled fishes

Reproduction

- All have internal fertilization
- Oviparous – lay eggs immediately after fertilization in yolky eggs – some lay them in a capsule called the “mermaid’s purse” – gestation is 6 to 9 months or 2 years in one species
- Ovoviviparous – retain the developing young in the uterus while they are nourished by the yolk sac -sand tigers have cannibalistic embryos
- True viviparous – embryos receive nourishment from the maternal bloodstream through the placenta – Blue, bull, hammerhead, lemon, mako
- Once the eggs are laid or young born, all parental care ends

Excretory

- Pair of kidneys – long slender above coelom drained to cloaca through use of wolffian ducts (also aids in reproduction)
- Retains large amounts of nitrogenous compounds (urea)
- These with blood salts raise the blood solute concentration to exceed the seawater
- Eliminates osmotic inequality

Rays

- Over half of all elasmobranchs are rays
- Skates(more triangular-all oviparous), electric rays, sawfishes, stingrays, eagle rays and manta rays
- Most are specialized for bottom dwelling
  - Dorsoventrally flattened
  - Enlarged pectoral fins fused to the head(wing-like)
  - Extended whip-like tail (sting rays – barbs with venom)
  - Gill openings are on the underside
  - Water for breathing is taken in through the spiracles (top of the head)
  - Teeth adapted to feeding on mollusks, crustaceans, and small fish

Subclass Holocephali : Chimaeras

- Ratfish, rabbitfish, spookfish, and ghostfish
- 31 extant species
- Large flat plates instead of teeth
- Upper jaw is completely fused to the cranium
- Feed on seaweed, mollusks, echinoderms, crustaceans, and fishes

Class Actinopteryfii: Ray-Finned Fishes

- Paleoniscids – small, big eyes, heterocercal tail, ganoid scales
- Chondrosteans – freshwater and anadromous sturgeons, paddlefish, and bichirs – heterocercal tail and ganoid scales –*Polypterus* African – with lungs
- Neopterygians – Genra – *Amia*(bowfin) and *Lepisosteus*(gar) – 7 species – elongate ambush predators with needle like teeth – gulp air to surface themselves

Telosts

- Perfect(teleos) bone(osteon)
- 23,600 species
- 96% of all fishes
- ½ of all vertebrates
- Est. additional 5-10 K species unidentified
- 10mm adult gobies to 9m oar fish to 4.5 m blue marlin
- Almost every habitat 5200 m in Tibet to 8000 m below the surface of the ocean – 44 Degrees Celsius to –2 degrees Celsius – salt concentrations 3 times that of seawater, caves of total darkness, swamps devoid of oxygen, or even extended excursions onto land (mudskippers)

Characteristics

- Skeleton more or less **bony** – caudal fin heterocercal(ancestral) or homocercal(advanced)
- Skin with mucous glands and embedded dermal scales: **ganoid**, **cycloid**, or **ctenoid** – some have **no scales** and some have **placoid**
- Median and paired fins with **fin rays of cartilage or bone(lepidotrichia);** muscles controlling fin movement within body
- Jaws present and teeth usually; olfactory sacs paired and do not open to the mouth; spiral valves present in ancestral absent in advanced
- Respiration by gills supported by bony fill arches and covered by an **operculum**

Characteristics

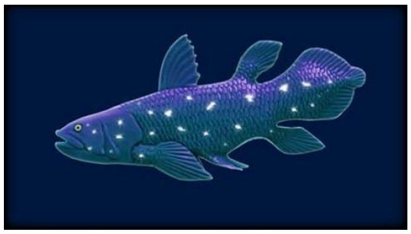
- **Swim bladder** often present with or without duct connected to pharynx
- Circulation consisting of a heart with sinus venosus, an undivided atrium, an undivided ventricle, single circulation, and four aortic arches
- Nervous system of brain with small olfactory lobes and cerebrum; large optic lobes and cerebellum; 10 pairs of cranial nerves
- **Sexes separate** (sex reversal in some), gonads paired; fertilization usually external; larval forms may differ greatly from adults

Special Stuff

- Nervous system - Lateral line detects movement: Well developed inner ear, no bones or eardrum
- Circulatory – Ventral aorta brings oxygen poor blood to the gills
- Digestive – Pyloric ceca increase the surface area for digestion similar to spiral valves
- Excretory – 50 to 90 percent of ammonia is release through the gills – kidneys =osmoregulators
- Reproduction – male – pair of testes for sperm through urogenital opening / female – single ovary release eggs through urogenital opening / many larva have a yolk sac for nutrients

Class Sarcopterygii: Lobe-Finned Fish

- 7 living species
  - Six belong to 3 genra of lungfishes
  - One is the coelacanth – survivor of a once abundant group
- All early sarcopterygians had lungs and gills and a heterocercal tail – Paired fins may have been used like feet to scuttle along the bottom



Lungfish

- Neocreatodus – new horn form – Australian
- Lepidosiren – pretty mythical mermaid – American
- Protopterus – first wing – African
  - Use lungs for long periods of time (rivers dry-burrows secretes a slime layer that makes a cocoon)
- Creates a sister lineage to amphibians

Class Amphibia

Kingdom Animalia, Phylum Chordata, Subphylum Vertebrata,

Class Amphibia : Tetrapods

From Water to Land

- Life originated in the water
- Animals are composed of mostly water
- So, why terrestrial habitat?
- Remember lungfish – adapted to life in the mud when the waters dried up? – Ah ha!
- Difference between land and water
  - (1) Oxygen content, (2) density, (3) temperature diffusion, (4) habitat diversity
- How did animals adapt?
  - (1) Lungs, (2) stronger muscular and skeletal systems, (3) live in warm climates (ecothermic) or become homoeothermic, (4) a good thing

Impact of Time

- Devonian period – time of fluctuating drought and floods. During the droughts, pools dried up and became void of dissolved oxygen.
- Only animals that adapted lungs were able to survive – "Survival of the most equipped" – Gills were unsuitable – lobe-finned fish had a kind of lung that was actually an outgrowth of the pharynx. All they had to do was make it better – increase the blood going to the lung.
- Limbs also developed during this period. Lobe-finned fishes used their strong fins like paddles to find other water holes. (Not initially intended for full-blown life on land)
- Land travel was simply and ironically a means for survival in water, but LUNGS and LIMBS prepared vertebrates for life on land.

Classification

- Caecilian
- Salamander
- Newt
- Frogs
- Toad

- Order Apoda– naked snake
- Order Caudata – having tail
- Order Anura – Without tail

Order Apoda: Caecilian

- 160 species
- Burrowing (Terrestrial) or Aquatic, therefore seldom seen by humans
- Elongate, Limbless, Small scales in the skin of some, many vertebrae up to 285, and a terminal anus
- Eyes are small, and most species are totally blind as adults
- Special sensory tentacles on their snout
- Diet of worms and small invertebrates
- Tropical rainforests of S America (1˚), Africa, and SE Asia
- Internal fertilization – male with a protrusible copulatory organ – eggs are deposited in moist ground near water - Larvae may be aquatic, or complete larval development may occur in the egg – in some species, eggs are guarded during their development in folds of the body – Viviparity also is common in some, with embryos eating the wall of the oviduct

Order Caudata: Salamanders

- 360 species
- Found in almost all northern temperate regions of the world – also in tropical areas of Central and northern South America
- Typically small (15 cm) – Aquatic Japanese giant salamander can get up to 1.5 m

Caudata – Body Features

- External
  - Limbs at right angles
  - Hindlimbs and Forelimbs approximately same size
  - Rudimentary or absent limbs in some aquatic or burrowing species
- Internal
  - Simple lungs
  - 3 chambered hearts

Caudata : Breeding

- Oviparous
- Mostly internal fertilization
- Spermatophore – sperm packet – laid on ground by male
- Female picks up spermatophore with oviduct – the vent (a special compartment of the oviduct) protects the sperm until fertilization
- Terrestrial species lay eggs in moist – surrounded by a coat of jelly to prevent drying – direct development (bypass the larval stage hatch as miniature versions of their parents
- Aquatic species lay eggs in clusters or stringy masses in water – larvae have external gills and a finlike tail
- Red eft stage – terrestrial juvenile

Caudata: Paedomorphosis

- Retention of juvenile forms into adulthood
- A striking example which occurs in Genus Necturus (mud puppies) is Perennibranchiate – the retention of juvenile gills while being sexually mature – will not undergo metamorphosis under any conditions
- The axolotols can undergo metamorphosis under certain environmental conditions (when their pond dries up, they develop lungs to find water suitable for reproduction) – can be artificially induced by using Thyroid hormones
- Paedomorphosis is observed in Genus Bolitoglossa, a terrestrial genra, in the pads of its hands and feet

Order Anura: Frogs and Toads

- 3,450 species of frogs and toads
- Larvae distinguish them from Caudata
- Aquatic reproduction and water-permeable skin keep them near a freshwater source
- Ectothermy keeps them away from the polar and subarctic habitats
- Found almost everywhere else

Anura: Body Features

- Tailless as adults except the genus *Ascaphus*
- Specialized for jumping
- Webbed feet
- Integument and Coloration
- Skeletal and Muscular Systems
- Respiration and Vocalization
- Circulation
- Feeding and Digestion
- Nervous System and Special Senses

Integument and Coloration

- Skin is thin and moist and only loosely attached at certain places
- Molts it epidermis which contains deposits of keratin (tough fibrous proteins that protect against abrasion and loss of water from the skin – Most terrestrial anura, including toads have especially heavy deposits of keratin)
- Small mucous gland secrete a protective water proofing on the skin's surface
- Large serous glands produce whitish, water poison
- Color is produced by chromatophores located mainly in the dermis – may be concentrated in a small area or dispersed throughout
  - Xanthophores – yellow, orange, or red
  - Iridophores – silvery light-reflecting
  - Melanophores – black or brown melanin
- Many frogs can adjust their color to blend in – camouflage

Skeletal and Muscular Systems

- Endoskeleton of bone and cartilage
- Vertebral column has lost much of its flexibility that the fishes has
- Specialized with a shortening of the body
- 9 trunk vertebrae and a urostyle
- Skull is vastly altered – flattened – fewer bones – anterior is better developed while the posterior is much reduced
- Appendicular bones and muscles present the typical tetrapod pattern – hip, knee, ankle or shoulder, elbow, wrist
- Foot is typically five rayed – pentadactyl and the hand is typically four rayed (jointed digits)
- Two major groups of muscles on any limb: anterior and ventral (protraction and adduction) & posterior and dorsal (retraction and abduction)

Respiration and Vocalization

- 3 respiratory surfaces: skin (cutaneous), mouth (buccal), and lungs
- Carbon dioxide mostly diffused across the skin while oxygen is absorbed primarily across the lungs
- Problem in lung evolution was not development of a good internal surface, but the problem of moving the air
- Positive-pressure breathers – which means that amphibians forcing air into the lungs
- Male and Female frogs have vocal cords located in the pharynx, but the males are much better developed
- Produce sound by passing air back and forth over the vocal cords between the lungs and a pair of vocal pouches in the floor of the mouth
- The males use the vocal pouches as resonators to enhance their mating calls
- Calls can be used as identifiers

Circulation

- Closed System
- Double Circulation – systemic circulation to the body and a pulmonary circulation to the lungs
- Frogs hearts have two separate atria and a single undivided ventricle
- Blood from the body (systemic circuit) first enters a large receiving chamber, the sinus venosus, which forces blood into the right atrium
- The left atrium receives freshly oxygenated blood from the lungs
- Both atria contract at the same time, driving both left and right atrial blood into the ventricle
- Even though the ventricle is undivided the blood remains mostly separated – therefore, when the ventricle contracts, oxygenated pulmonary blood enters the systemic circuit and deoxygenated systemic blood enters the pulmonary circuit – aided by the spiral valve, which divides the systemic and pulmonary flow in the conus arteriosis

Feeding and Digestion

- Carnivorous like most other adult amphibians
- Feed on insects, spiders, worms, slugs, snails, millipedes, and nearly anything else that moves and is small enough to swallow whole
- They snap at moving prey with their protrusible tongue which is connected to the front and is free behind
- Glandular free end of the tongue produces a sticky secretion that adheres to prey
- When teeth are present, they are to prevent escape of prey, not for biting
- The digestive track is relatively short which produces a variety of enzymes for digestion
- Tadpoles are usually herbivorous feeding mostly on pond algae, therefore they have a relatively long intestinal tract

Nervous System and Special Senses

- 3 part brain – forebrain (sense of smell), midbrain (vision), and hindbrain (hearing and balance)
- Blinking evolved as a means to keep the eyes moist

Reproduction

- Through amplexus (clasping), external fertilization occurs
- As a female lays eggs, the male discharges sperm over the eggs to fertilize them
- The jelly layers absorb water and swell
- Eggs are laid in large masses, usually anchored to vegetation
- Biphasic life cycle –aquatic larvae, terrestrial adult

Overview of Amphibians

1. Skeleton mostly of bone, with varying numbers of vertebrae; ribs present in some, absent or fused to vertebrae in others; notochord does not persist; exoskeleton absent
2. Body forms vary greatly
3. Limbs usually four (tetrapod), although some are legless; forelimbs present; no true nails or claws; forelimb usually with four digits but sometimes five and sometimes fewer
4. Skin smooth and moist with many glands, some of which may be poison glands; pigment cells common, of considerable variety; no scales except concealed dermal ones
5. Mouth usually large with small teeth in upper or both jaws; two nostrils open into anterior part of mouth cavity

Overview cont'd

6. Respiration by lungs (absent in some salamanders), skin and gills in some, either separately or in combination; external gills in larval forms and may persist throughout life in some
7. Circulation with three-chambered heart, two atria and one ventricle, and a double circulation through the heart; skin abundantly supplied with blood vessels
8. Ectothermal
9. Separate sexes; fertilization mostly internal in salamanders and caecilians, moslty external in frog and toads; predominantly oviparous some ovoviviparous or viviparous metamorphosis usually present moderately yolky eggs with jellylike membrane coverings

Reptiles

•*Reptiles* include the extinct dinosaurs and today's snakes, lizards, turtles, alligators, and crocodiles.

•Reptiles have *well-developed lungs* within a rib cage; they are covered with *scales* that protect them from desiccation and predators.

•Reptiles have *internal fertilization* and also lay a *shelled egg*, which contains *extraembryonic membranes*, including an *amnion* that allows the embryo to develop on land.

•Features that distinguish reptiles include:

•*Usually tetrapods*

•*Lungs with expandable rib cages*

•*Shelled, leathery egg*

•*Dry, scaly skin*

•Fishes, amphibians, and reptiles are ectothermic.

•Reptiles try to regulate their body temperature by moving to a warmer or cooler location as needed.

Classification

Order	Examples
Order Chelonia (Testudines)	**Tortoise and turtles**
Order Squamata	**Lizards and snakes**
Order Sphenodonta	**tuatara**
Order Crocodilia	**Alligators and crocodiles**

Order Testudines

•Enclosed in shells consisting of a dorsal carapace and a ventral plastron, individual plates are scutes

•Jaws are horny beaks instead of teeth

•Oviparous with internal fertilization – bury eggs

•In some, nest temperature determines sex of offspring

–Sea turles - the eggs in the lower, cooler, part of the nest will become males, while the eggs in the upper, warmer, part of the nest will become females.

•Vertebrae and ribs are fused to carapace – can't walk out of shell like in the cartoons

•Tongue is not extendable

•Neck is usually retractable

Chart of Endangered Species of Sea Turtles

Common Name	Scientific Name	ESA status
Green turtle	Chelonia mydas	Endangered/ Threatened
Hawksbill turtle	Eretmochelys imbricata	Endangered
Kemp's ridley turtle	Lepidochelys kempii	Endangered
Leatherback turtle	Dermochelys coriacea	Endangered
Loggerhead turtle	Caretta caretta	Threatened
Olive ridley turtle	Lepidochelys olivacea	Endangered/ Threatened

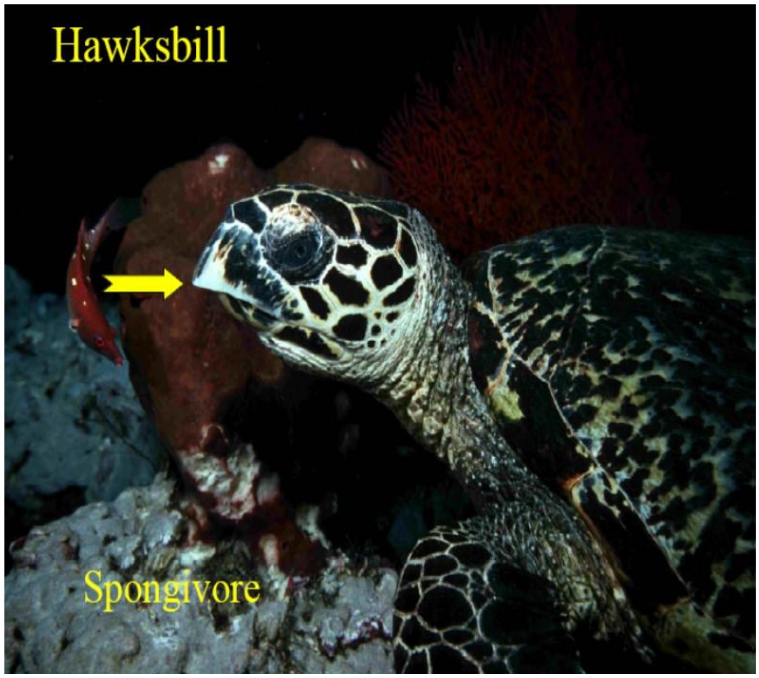
Alligator Snapping Turtle

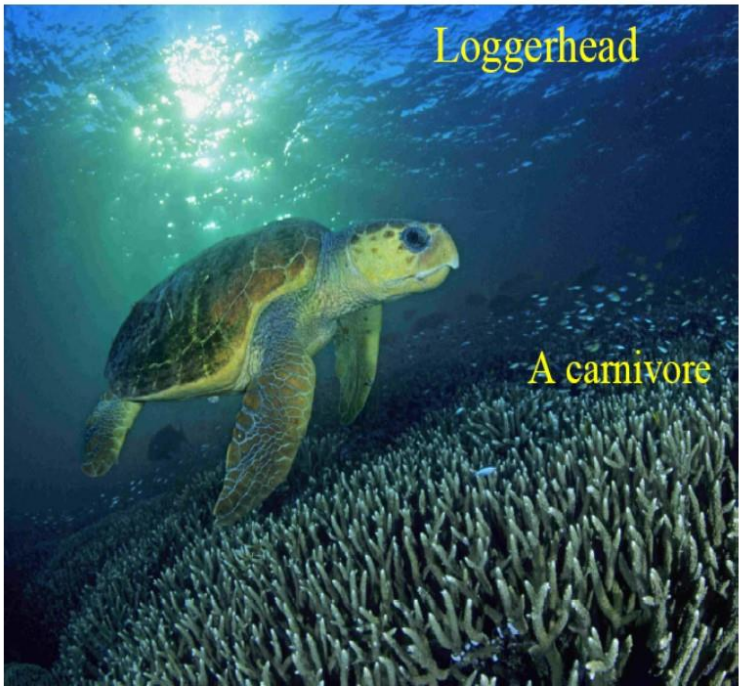
- The Alligator Snapping Turtle can weigh up to 200 pounds or more.
- It is the worlds largest fresh water turtle.
- The turtle's shell can grow to 26 inches.
- #6 on WWF Endangered list

- Is the largest fresh water turtle.

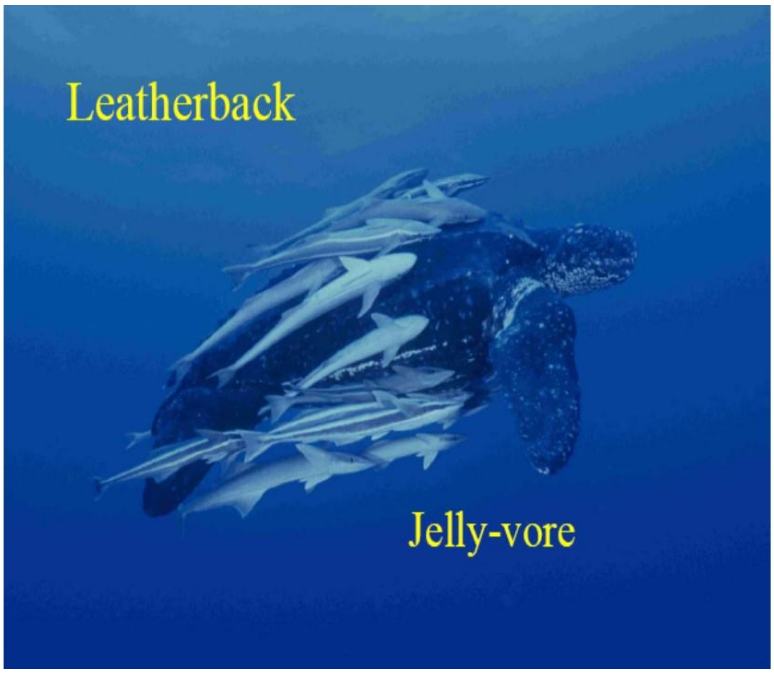
* endangered in Kentucky, Indiana, Illinois, and Missouri, where they are protected by state law. They are designated as "in need of conservation" in Kansas.


Green Turtle
Herbivore-eats sea grasses and algae


Hawksbill
Spongivore


Loggerhead
A carnivore


A carnivore
Kemp's Ridley



Order Squamata

•Suborder Sauria – lizards

–Usually four limbed

–Moveable eyelids

–External ear opening

–Komodo dragon, geckos, iguanas, skinks, chameleons

•Legless lizards – still have external ears, eyelids and is a lot shorter and smaller

Order Squamata

- Suborder Serpentes – snakes
  - –Largest suborder
  - –No limbs
  - –No ear openings
  - –Eyes are lidless and immovable
  - –Carnivorous
  - –Most are non poisonous
    - •Constrictors – eat whole prey
  - –Others are poisonous
    - •Hemotoxins – destroys red blood cells and alters blood clotting
    - •Neurotoxins – interfers with function of nervous system
  - –Most are oviparous

Order Sphenodonta – Tuatara

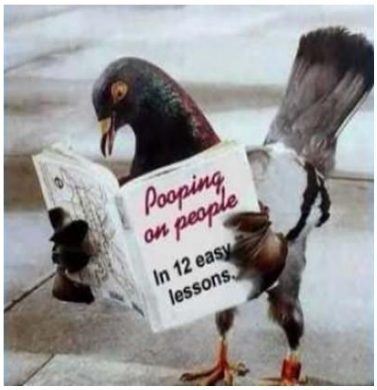
- http://www.teara.govt.nz/en/tuatara
- Long living lizard-like creature
- Well developed eye complete with elements of cornea, lens, and retina buried beneath the skin
- Third eye can register only changes in light intensity
- Almost identical to its 200 million year old fossil relatives

Order Crocodilia – crocodiles and alligators

- Carnivorous
- Four chambered heart
- Oviparous
  - –Mating = mid April through May
  - –Clutch size = 20-50 eggs
  - –Gestation = 60-65 days
- Incubation temperature effects sex
  - –86 degrees F = female
  - –93 degrees F = male

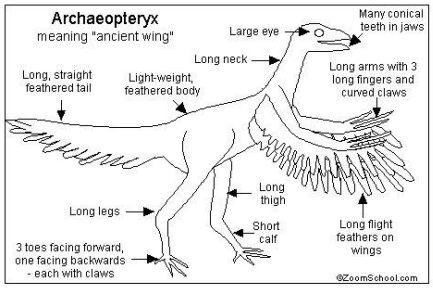
Class Aves

- *Birds* are characterized by the presence of *feathers*, which are modified reptilian scales.
- Birds lay *hard-shelled eggs* rather than the leathery eggs of reptiles.
- Birds are likely closely related to bipedal dinosaurs, although this is still under study.
- More than 9000 species



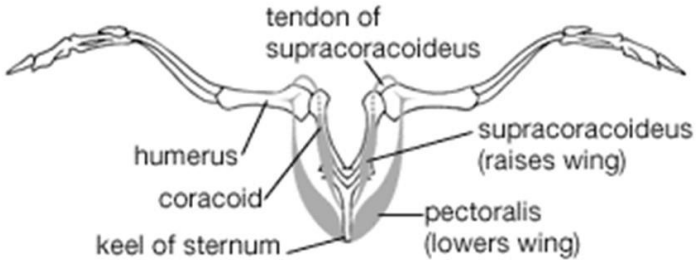
Archaeopteryx

- 150 million year old fossil
- From 1861 to 1987 six specimens found
- Thought to be transitional between reptiles and modern birds



• Anatomy and Physiology of Birds

- Features of birds are related to the ability to fly.
- Bird forelimbs are modified as *wings*.
- Bones are *hollow* and laced with air cavities; the sternum has a *keel* to which flight muscles attach.
- A horny *beak* replaces teeth.
- Respiration is efficient due to *air sacs*.
- Birds have a *four-chambered heart*, and birds are *homeothermic*.



Pectoralis – depresses wings in flight

Supracoracoideus – raises the wing

Rope & pulley system

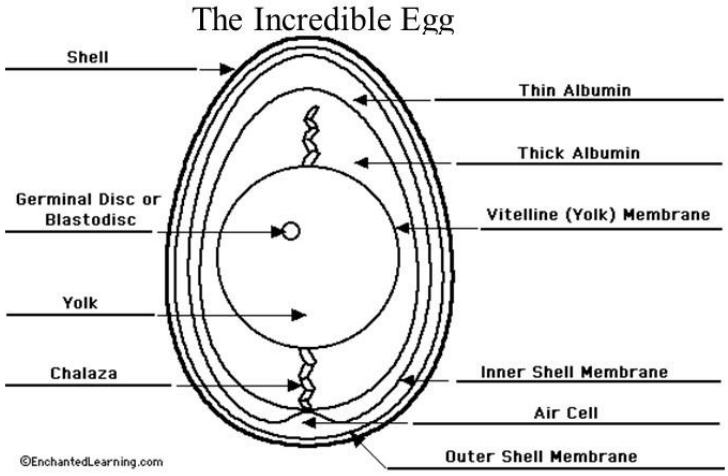
Main muscle mass low in the body improves aerodynamics & stability

• Classification of Birds

- The classification of birds is based on beak and foot types and to some extent on habitat and behavior.
- 27 extant orders and a few fossil orders
- These features distinguish birds:
  - *Feathers*
  - *Hard-shelled egg*
  - *Four-chambered heart*
  - *Usually wings for flying*
  - *Air sacs*
  - *Homeothermic*

Reproduction

- More than 90% of birds are monogamous
- Female typically only left ovary develops
- Young are either precocial or altricial
  - Precocial (covered with down) can run or swim and include most water birds
  - Altricial (helpless and naked)



air cell - an empty space located at the large end of the egg; it is between the inner and outer shell membranes.

chalaza - a spiral, rope-like strand that anchors the yolk in the thick egg white. There are two chalazae anchoring each yolk; one on the top and one on the bottom. (The plural of chalaza is chalazae.)

germinal disc - a small, circular, white spot (2-3 mm across) on the surface of the yolk; it is where the sperm enters the egg. The nucleus of the egg is in the blastodisc.

shell - the hard, protective coating of the egg. It is semi-permeable; it lets gas exchange occur, but keeps other substances from entering the egg. The shell is made of calcium carbonate.

albumin - the egg white.

yolk - the yellow, inner part of the egg where the embryo will form. The yolk contains the food that will nourish the embryo as it grows.

Order	example
Gruiformes	Cranes, rails, coots, gallinules
Charadriiformes	Gulls, plovers, sandpipers, terns
Piciformes	Woodpeckers, toucans,
Falconiformes	Falcon, eagle, hawk, vulture, buzzard condor
Strigiformes	owls
Pelecaniformes	Frigatebird, pelicans, boobies
Sphenisciformes	penguins
Ciconiiformes	Herons, egrets, storks, ibises, spoonbills, flamingos

Do we have flamingoes? NO!

Order Ciconiiformes includes herons, egrets, storks, ibises, spoonbills and flamingoes (about 90 species worldwide)

This is a Rosette Spoonbill – found in LA swamp areas.

Why are some of our beaches restricted?

Order Charadriiformes includes gulls, plovers, sandpipers, terns, woodcocks (about 330 species worldwide)

This is the eastern least tern – one of three subspecies (California and Interior)

Our most endangered species?

Mississippi Sandhill Crane (*Grus canadensis pulla*) of Order Gruiformes (about 215 species worldwide – only 15 species of cranes) also include rails, coots and gallinules.

About 110 individuals with 20 mating pairs

Cranes **Order Gruiformes**	**Herons and Egrets** **Order Ciconiiformes**
Fly with neck outstretched	Fly with recurved neck
Bare red crown	Fully feathered head
Loud, rattling bugle call	Croak call
Long-lived (15-20 yrs)	Short-lived
Monogamous	Change mates
Nest on ground, solitary	Nest in tree, colonial
Lay 1-2 eggs	Lay 4-7 eggs
Parents take chick to food	Parents take food to chick
Young stay with parents 10 months	Parents desert young after fledging (?? months)
Long subadult period (3-8 years)	Breed at 1-2 years

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One of my favorites – osprey (sea eagle)
Order Falconiformes – eagles, hawks, vultures, falcons, condors, buzzards – diurnal birds of prey – about 270 worldwide species

Magnificent Frigatebird *Fregata magnificens* – kleptoparasite (steals from gulls)
Order Pelecaniformes – throat pouches (pelicans, cormorants, gannets, boobies and others) about 55 species worldwide

Class Mammalia

- Separated into 2 subclasses, one extinct, other extant
- Second subclass is divided into three infraclasses
- Montremes and marsupials are each in their own infraclass
- All placental mammals are in Infraclass Eutheria with 19 orders

Order Montremata

- Egg-laying (oviparious) mammals
- Include duck bill platypus and spiny ant eater (echidna)
- Duck bill platypus found in Tasmania and Australia
- Two species of echidna is found in Australia, Tasmania, and New Guinea
- All montremes nourish young with milk

Order Marsupialia

- Pouched mammals
- Include opposums, kangaroos, koala, tasmanian devils, wombats, wallaby, and bandicoots
- 260 species with most representatives in Australia and some in Americas

Order Insectivora

- Insect-eating mammals
- Include shrews, hedgehogs, and moles
- 390 species with small sharp-snouted animals with primitive characteristics

Order Chiroptera

- Flying mammals
- 986 species of bats
- Use of echolocation and mostly nocturnal

Order Primates

- First in the animal kingdom in brain development with especially large cerebral hemispheres
- Include prosimians, monkeys, apes, humans
- Prosimians include lemurs, tree shrews, tarsiers, lorises, and pottos (primates restricted to the tropics of the Old World)
- Five digits on both fore and hind limbs
- 233 species

Order Xenarthra

- Either toothless (anteaters) or with simple peglike teeth (sloths and armadillos)
- 30 species restricted to South and Central America
- Exception is nine banded armadillo in southern US

Order Lagomorpha

- Dentition resembling rodents but with four upper incisors
- 69 species including rabbits, hares, and pikas

Order Rodentia

- Gnawing mammals
- 1814 species including squirrels, rats, and woodchucks
- Most numerous of all mammals in numbers and species
- Dentition with two upper and lower chisel-like incisors that grow continually

Order Cetacea

- One of three orders of water mammals
- Includes 79 species of whales, dolphins, and porpoises
- Anterior limbs modified into broad flippers with posterior limbs absent
- Nostrils are single or double blow hole on top of head
- When teeth are present, all alike and lacking enamel

Order Carnivora

- Flesh-eating mammals
- Includes 240 species of dogs, wolves, cats, bears and weasels
- Some of the most intelligent and strongest of animals
- All with predatory habits
- Teeth especially for tearing flesh

Order Pinnipedia

- Second order of water mammals
- Includes 34 species of sea lions, seals, sea elephants, and walruses
- Carnivores with limbs modified into flippers for swimming
- All marine; food consists mostly of fish

Order Proboscidea

- Only two species remain extant
- Indian elephant with relatively small ears
- African elephant with larger ears

Order Perissodactyla

- Odd-toed hoofed mammals
- Include 17 species of horses, asses, zebras, tapirs, and rhinoceroses
- All herbivorous with teeth adapted for chewing
- Often referred to as ungulates

Order Artiodactyla

- Even-toed hoofed mammals
- Includes 211 species of swine, camels, deer, hippopotamuses, giraffes, antelopes, cattle, proghorn, sheep, and goats
- Many with horns
- Many are ruminants (partitioned stomachs)
- Also referred to as ungulates

MANATEE AWARENESS HISTORY

- The Manatee has roamed the earth for over ten thousand years.
- The Manatee evolved from the African and Eurasian elephant.
- The Manatee can live up to the age of 50 to 60 years old.
- They abandoned land for the sea.
- The Manatee eats on sea grasses and can go through 30 sets of teeth through its lifespan.

MANATEE AWARENESS BIOLOGY

- There are five species of Manatees

1. The West Indian Manatees
2. The West African Manatee
3. The Amazonian Manatee
4. The Dugong Manatee
5. The Steller's Sea Cow

MANATEE AWARENESS
BIOLOGY

- The West Indian Manatee lives primarily in Florida's waterways. This Manatee can grow up to 13ft in length and weigh around 2,500 pounds.
- They are air breathing mammals.
- They give birth to their young.
- They have hairs on their body just like humans (they can use these hairs to tell change in weather and water temperature).
- The gestation period is about 13 months.

The new born calves will stay with the mom for approximately for 2 – 2 ½ years.

- They will go through 30 sets of teeth throughout their lifespan.

MANATEE AWARENESS
BIOLOGY

The West Indian Manatee does not like the cold water. This is why it stays in Florida's warm 72 degree spring water during the winter months.

The Manatees are susceptible to colds, pneumonia, dehydration; just like Humans.

The Manatees will migrate in from the cold water to the warm springs in the winter months: November thru March.

The manatees are vegetarians. They can digest small shrimp and fish that get caught in the grasses they eat. This is where they get some of their protein.

MANATEE AWARENESS BIOLOGY

The **West African Manatee** Habitats in West African Coastal Areas. Very little is known about the West African Manatee. Very few studies have been made on this species. The West African Manatee is similar in habitats and appearance as the West Indian Manatee.

MANATEE AWARENESS BIOLOGY

The **Amazonian Manatee**; smooth skin, no nails on flippers. Found in the fresh waters of the Amazon River and tributaries. Feeds on fresh water vegetation. The Amazonian Manatee is still pressured by hunting, from the tribal natives.

MANATEE AWARENESS BIOLOGY

The Dugong Manatee; smooth skin, notched tail fluke, without nails on flippers, habitats on marine grasses. Found in the Indo-Pacific region, Asia and Australia areas. Hunted for food by native people. Feeds on marine grasses and the mature Dugong can still grow tusks like an elephant.

MANATEE AWARENESS BIOLOGY

The Steller Sea Cow; dark gray, heavy textured skin, forked tail fluke, toothless. Up to 30 ft in length.

Weight: 3 ½ tons. Formerly found in the arctic waters of the Bering Strait.

Hunted into extinction within 27 years of it's discovery in 1741.

Phylum Chordata

3 Subphyla (list of three + examples)

Characteristics of the Phylum

- _____- **A firm, flexible rod of specialized cells that becomes the endoskeleton in vertebrates.**
- _____ - **A hollow tube above the notochord that becomes the spinal chord and brain in vertebrates**
- _____- **Out-pockets in the pharynx, the portion of the digestive tract between the mouth and the esophagus. - Become _____and _____ in aquatic chordates.**
- **Become jaws, inner ear, and tonsils in terrestrial chordates.**
- _____- **A tail located posterior to the anal opening**

Subphylum Cephalochordata

- About 24 species of Lanceletes - _____ in North America
- Originally named _____ (sharp at both ends) - Separate Sexes (_____)

Subphylum Urochordata

- About _____ species of Tunicates - Covered by a tough covering, or tunic
- 3 classes - _(1)Class _____ - most common - Includes _____ - Sessile
- (2) Class _____ - Builds transparent mucosal houses
- (3) Class _____ - Mobile-jet propulsion
- Tadpole larvae has all 4 hallmarks of chordates, adults have but one.
- **Water travels in the Incurrent Siphon through the pharynx (_____) that leads to the stomach, food travels through the intestine to the anus and out the excurrent siphon**
- **tolons act as holdfasts (_____) & Hermaphroditic**
- **Heart (beating one way then the other)**

Subphylum Vertebrata

Anatomical Characteristics

- _____ system – scales, hair, skin, feathers, sweat glands
- _____ system – muscle is attached to bone, used for locomotion and also aids in other systems.
- _____ system – made up of bone or cartilage. Basic two part division – axial or appendicular (pelvic or pectoral)
- _____ system – special features differ for each class
- _____ system – gills or lungs or both
- _____ system – closed system, heart, vessels with arteries/veins
- _____ system – certain organ function to remove wastes
- _____ system – hormonal production and secretion
- _____ system – Cephalization, development of highly specialized sensory structures and a highly specialized brain
- _____ system – separate organs for reproduction - External (fish or amphibian or Internal (reptile or bird or mammal)

Chordates

- *Chordates* (tunicates, lancelets, and vertebrates) have:
- a supporting *notochord*,
- a *dorsal hollow nerve cord*,
- *pharyngeal pouches*, and a
- *post-anal tail* at one time during their development.

Superclass Agnatha
Phylum Chordata
Subphylum Vertebrata

- 84 species
  2 classes
    Myxini - (_____)
    Cephhalaspidomorphi - (_____)
- Separated due to morphological differences

Class Myxini : Hagfishes

- _____ – osmotic equilibrium
- Feed on annelids, mollusks, crustaceans, and dead or dying fishes
- Not parasitic – _____ and _____
- Almost blind – good _____ and _____ senses
- Either enters an orifice or digs inside of dead fish
- Ties a _____ in its tail for extra leverage
- No _____ stage
- Secretes a mucosal covering
- Female outnumber the males 100 to 1
- Produce yolky eggs .

Class Cephalaspidomorphi: Lampreys

- About 22 species in North America
- Some are _____ (feeding) others are non-feeders
- Marine or Freshwater
- But are stream spawners (_____)

Lamprey's Reproduction

- Male builds a nest and is later joined by the female
  male attaches to a rock with her mouth. The male attaches to the side of her head.
- External Fertilization occurs (_____)
- Sticky eggs stick to the nest and are covered by sand
- Adults _____ soon after spawning
- Eggs hatch – _____ larvae
- Leaves rock nest and burrows in a sandy low-current area
- 3 to 7 or more years underground
- Parasitic lampreys use their teeth to hold onto a fish and rasp at the flesh to suck out the fluids
- Anticoagulant

Great Scott!!
The Great Lakes are Invaded

- In 1829 the _____ Canal was built
- Prior to this and 100 years after this, no lampreys were seen in Lake Erie
- By mid _____ the sea lamprey was causing extraordinary damage to all the Great Lakes
- Lampreys preferred lake trout, a multimillion dollar industry
- It was brought to a total collapse by _____
- Then attacked yellow perch, whitefish, rainbow trout, and lake herring – all important industry fish
- Numbers began to decrease in the late 1950's and early 1960's – partly due to depletion of food supply and also human control methods (chemical _____)
- Experimenting with _____ _____

Form and Function

Pointed mouth – _____

Fins – paired _____ & paired _____ = modified for copulation in some male species (_____)

One or Two dorsal – each with a _____ in *Squalus* (_____) & One Caudal (_____)

Paired Nostrils & Lateral lidless eyes – _____ eyelids in certain species

5 gills _____ anterior to the pectoral fin (_____)

_____ scales – reduces turbulence – creates a tough leather like dermal layer

Ecology of Sharks

- _____ - Highly adapted to a predatory life
- Track their prey using highly sensitive senses in an orderly sequence – 1st is _____
- Detect from a kilometer or more away with their large _____ organs – 1ppb
- Mechnoreceptors in their _____ system to detect vibrations
- _____ is used at closer range (primary)

Digestion

- Upper and Lower jaws have many sharp triangular _____ (rows)
- Mouth cavity opens into a large _____ (contains opening to the gill slits - respiration)
- Short, wide _____ runs to a J-shaped _____
- The _____ & _____ open into the short, straight intestine which contains the spiral _____ slows down food to increase absorption)
- Short _____ that leads to the _____(unique to chondrichthyes – secrets a colorless fluid ontaining a high concentration of NaCl – assist kidney in NaCl regulation in the the blood)

Circulatory

- _____ chambered heart - _____ circulatory system - Typical of gilled fishes

Reproduction

- All have _____ fertilization
- _____ – lay eggs immediately after fertilization in yolky eggs – some lay them in a capsule alled the "_____ purse" – gestation is 6 to 9 months or 2 years in one species
- _____ – retain the developing young in the uterus while they are nourished by the yolk sac
- True _____ – embryos receive nourishment from the maternal bloodstream through the lacenta – sand tigers have cannibalistic embryos
- Once the eggs are laid or young born, all parental care ends

Excretory

- Pr _____ – long slender above coelom drained to cloaca through wolffian ducts (also aids in reproduction)
- Retains large amounts of _____ compounds (urea)
- These w/blood salts raise the blood solute % to exceed the seawater - Eliminates _____ inequality

Rays

- Over half of all elasmobranchs are _____
- Skates(more triangular-all _____), electric rays, sawfishes, stingrays, eagle rays and manta rays
- Most are specialized for _____
- _____ flattened & Enlarged _____ fins fused to the head(wing-like)
- Extended whip-like tail (sting rays – _____ with venom)
- Gill openings are on the _____
- Water for breathing is taken in through the _____ (top of the head)
- Teeth adapted to feeding on mollusks, crustaceans, and small fish

Subclass Holocephali : _____

- Also called _____, rabbitfish, spookfish, and ghostfish - _____ extant species
- Large flat _____ instead of teeth & Upper jaw is completely fused to the _____
- Feed on _____, _____, _____, _____, and _____

Fishes

•Today there are _____ living classes of fishes: jawless fishes, cartilaginous fishes, and bony fishes – the last two groups have _____.

'ess Fishes

ıe first vertebrates were *jawless fishes*, today represented by _____ & _____ with no scales or paired fins. - Water moves in and out through _____.

•Cartilaginous Fishes

•The *cartilaginous fishes* include the sharks, rays and skates which have skeletons made of _____.

• _____ and _____ are flat fishes that live partly buried in the sand and feed on mussels and clams.

•*Sharks* and rays have a sense of electric currents in water, a *lateral line system*, and a keen sense of smell; these attributes help detect prey.

•Bony Fishes

• _____ have jaws and _____ pairs of fins & are the most diverse & numerous of all vertebrates.

•Bony fishes include those that are _____ (most abundant) and a few that are _____; some of the lobed-finned fishes have lungs and likely gave rise to amphibians.

•A _____ may provide buoyancy in ray-finned fishes.

•Most fishes today are ray-finned and have these characteristics: (6)

ss Chondrichthyes

aginous Fishes

Class Characteristics

- About _____ extant species
- Completely boneless class
- Odd because Chondrichthyes are derived from ancestors having well developed _____
- Almost all are _____
- _____ species live primarily in fresh water

Subclasses

- Subclass Elasmobranchii (3 examples) _____, _____, & _____
- Subclass Holocephali (1 example) _____

Subclass Elasmobranchii

- About _____ species
- Nine living orders
  - Order Carcharhiniformes (2 examples)_____ & _____
  - Order Lamniformes (2 examples) _____ & _____
  - Order Squaliformes (1 example) _____
  - Order Rajiformes (2 examples) _____ & _____

Shark Attacks

- nature, sharks are _____ and _____
- st shark attacks are _____ induced (stupidity factor)
- _____ and _____ waters have the most shark attacks recorded
- WWII ships that sank created mass shark attacks

Class Actinopteryfii:
Ray-Finned Fishes

- _____ – small, big eyes, heterocercal tail, ganoid scales
- _____ – freshwater and anadromous (_____) sturgeons, paddlefish, and bichirs – heterocercal tail and ganoid scales –*Polypterus* African – with lungs
- _____ – Genra – *Amia*(bowfin) and *Lepisosteus*(gar) – 7 species – elongate ambush predators with needle like teeth – gulp air to surface themselves

Telosts (_____)

- Perfect(teleos) bone(osteon)
- _____ species - _____ of all fishes & _____ of all vertebrates
- Est. additional 5-10 K species unidentified
- Size range from _____ adult gobies to _____ oar fish to _____ blue marlin
- Almost every habitat 5200 m in Tibet to 8000 m below the surface of the ocean – 44 Degrees Celsius to –2 degrees Celsius – salt concentrations 3 times that of seawater, caves of total darkness, swamps devoid of oxygen, or even extended excursions onto land (mudskippers

Characteristics

- Skeleton more or less _____ – caudal fin heterocercal(_____) or homocercal(_____)
- Skin with mucous glands and embedded dermal scales: _____, _____, or _____ – some have _____ and some have _____
- Median and paired fins with **fin rays of cartilage or bone(lepidotrichia);** muscles controlling fin movement within body
- Jaws present and teeth usually; _____ sacs paired and do not open to the mouth; spiral valves present in ancestral absent in advanced
- Respiration by _____ supported by bony fill arches and covered by an _____

Characteristics

- _____ often present with or without duct connected to pharynx
- Circulation consisting of a heart with _____, an undivided atrium, an undivided ventricle,(_____) single circulation, and four aortic arches
- Nervous system of brain with small olfactory lobes and _____; large optic lobes and _____; 10 pairs of cranial nerves
- _____ (sex reversal in some), gonads paired; fertilization usually external; larval forms may differ greatly from adults

Special Stuff

- Nervous system - _____ detects movement: Well developed _____ ear, no bones or eardrum
- Circulatory – Ventral aorta brings oxygen poor blood to the gills
- Digestive – _____ increase the surface area for digestion similar to spiral valves
- Excretory – _____ percent of ammonia is release through the gills – kidneys =_____
- Reproduction – male – _____ of testes for sperm through urogenital opening / female – _____ ovary release eggs through urogenital opening / many larva have a yolk sac for nutrients

Class Sarcopterygii:
Lobe-Finned Fish

- _____ living species

–Six belong to 3 genra of lungfishes
–One is the _____ – survivor of a once abundant group

- All early sarcopterygians had lungs and gills and a heterocercal tail – Paired fins may have been used like feet o scuttle along the bottom

Lungfish

- _____ – new horn form – Australian
- _____ – pretty mythical mermaid – American

•_____ – first wing – African

–Use lungs for long periods of time (rivers dry-burrows secretes a slime layer that makes a cocoon)

•Creates a sister lineage to _____

Characteristics

•Skeleton more or less _____ – caudal fin heterocercal(ancestral) or diphycercal

•Skin with embedded dermal scales: **ganoid**, **cycloid**, or **ctenoid** – some have _____ and some have **placoid**

•_____ and _____ fins with a single basal skeletoal element and short dermal rays; muscles that move paired fins are located on limb

•Jaws present and teeth covered with _____ and typically are crushing plates restricted to palate; olfactory sacs paired and may or may not open to the mouth; spiral valves in intestine

•Respiration by gills supported by bony arches and covered by an _____

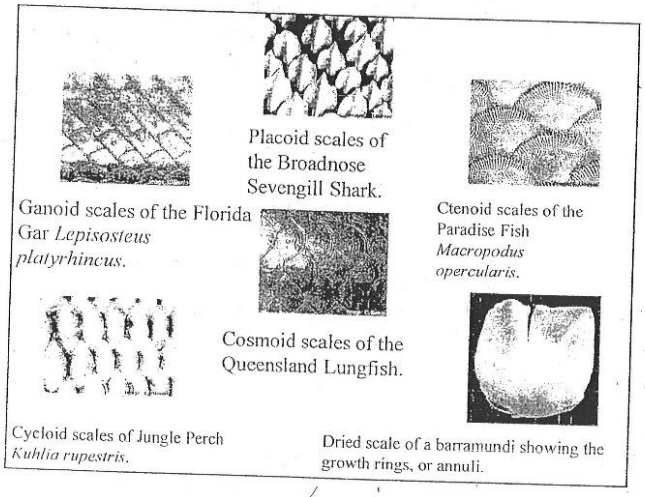
Characteristics

•_____ for respiration and buoyancy (_____ filled in coelacanth)

•Circulation consisting of a heart with sinus venosus, two atria, a partly divided ventricle, and a conus arteriosis, _____ with pulmonary and systemic circuits, and typically five aortic arches

•Nervous system of brain with small olfactory lobes and _____; large optic lobes and _____; 10 pairs of cranial nerves

•_____ (_____) fertilization external or internal



Class Amphibia

A NEW DISCOVERY!!!

➢Found in Canadian Arctic in 2004 by **Neil Shubin** (University of Chicago), **Edward (Ted) Daeschler** (Academy of Natural Sciences of Philadelphia) and **Farish A. Jenkins, Jr.** (Harvard University).

http://tiktaalik.uchicago.edu/

From Water to Land

➢Life originated in the _____

➢Animals are composed of mostly water

➢So, why terrestrial habitat? Remember lungfish – adapted to life in the mud when the waters dried up?

➢Difference between land and water

- (1) _____ content, (2) _____, (3) _____ diffusion, (4) habitat _____

➢How did animals adapt?

•(1) _____, (2) stronger muscular and skeletal systems, (3) live in warm climates (_____) or become homoeothermic, (4) a good thing

Impact of Time

➢_____ period – time of fluctuating drought and floods. During the droughts, pools dried up and became void of dissolved oxygen.

➢Only animals that adapted lungs were able to survive – "Survival of the most equipped" – Gills were unsuitable – _____ fish had a kind of lung that was actually an outgrowth of the pharynx. All they had to do was make it better – increase the _____ going to the lung.

➢_____ also developed during this period. Lobe-finned fishes used their strong fins like paddles to find other water holes. (Not initially intended for full-blown life on land)

➢Land travel was simply and ironically a means for survival in water, but _____ & _____ prepared vertebrates for life on land.

Classification

Order Apoda– "_____ _____"

Order Caudata – "_____ _____"

➢ Order Anura – "_____ _____"

Part of History

Order Apoda: Caecilian

➢_____ species

➢Burrowing (Terrestrial) or Aquatic, therefore seldom seen by humans

➢Elongate, _____, Small scales in the skin of some, many vertebrae up to 285,& a terminal anus

➢Eyes are _____, and most species are totally blind as adults

➢Special sensory _____ on their snout

➢Diet of worms and small invertebrates

➢Tropical _____ of S America (1°), Africa, and SE Asia

➢Internal _____ – male with a protrusible copulatory organ – eggs are deposited in moist ground near water -Larvae may be aquatic, or complete larval development may occur in the egg – in some species, eggs are guarded during their development in folds of the body – _____ also is common in some, with embryos eating the wall of the oviduct

Order Caudata: Salamanders

➢_____ species

➢Found in almost all northern temperate regions of the world – also in tropical areas of Central and northern South America

➢Typically small (15 cm) – Aquatic Japanese giant salamander can get up to 15 m

➢Difference between newts and salamanders? _____

Caudata – Body Features

External

•Limbs at right angles

•Hindlimbs and Forelimbs approximately _____ size

•Rudimentary or absent in some aquatic or burrowing species
➢*Internal*
•Simple _____
•_____ chambered hearts
Caudata : Breeding
➢_____ - Mostly internal fertilization
➢_____ – sperm packet – laid on ground by male
➢Female picks up spermatophore with oviduct – the vent (a special compartment of the oviduct) protects the sperm until fertilization
➢Terrestrial species lay eggs in moist – surrounded by a coat of jelly to prevent drying – _____ development (bypass the larval stage hatch as miniature versions of their parents
➢Aquatic species lay eggs in clusters or stringy masses in water – larvae have external gills and a finlike tail
➢Red _____ stage – terrestrial juvenile
Caudata: _____ - Retention of juvenile forms into adulthood
➢A striking example which occurs in Genus _____ (mud puppies) is Perennibranchiate – the retention of juvenile gills while being sexually mature – will not undergo metamorphosis under any conditions
➢The _____ can undergo metamorphosis under certain environmental conditions (when their pond dries up, they develop lungs to find water suitable for reproduction) – can be artificially induced by using _____ hormones
➢Paedomorphosis is observed in Genus Bolitoglossa, a terrestrial genra, in the pads of its hands and feet

Order Anura: Frogs and Toads

➢_____ species of frogs and toads
➢Larvae distinguish them from Caudata
➢Aquatic reproduction and water-permeable skin keep them near a freshwater source
➢_____ keeps them away from the polar and subarctic habitats
➢Found almost everywhere else

Anura: Body Features

➢Tailless as adults except the genus _____
➢Specialized for jumping - _____ feet

Integument and Coloration

•Skin is _____ & _____ and only loosely attached at certain places
•Molts it epidermis which contains deposits of _____ (tough fibrous proteins that protect against abrasion and loss of water from the skin – Most terrestrial anura, including toads have especially heavy deposits of keratin)
•Small _____ gland secrete a protective water proofing on the skin's surface
•Large _____ glands produce whitish, water poison
•Color is produced by _____ located mainly in the dermis – may be concentrated in a small area or dispersed throughout
•_____ – yellow, orange, or red
•_____ – silvery light-reflecting
•_____ – black or brown melanin
•Many frogs can adjust their color to blend in – _____

Skeletal and Muscular Systems

➢Endoskeleton of bone and cartilage
➢_____ _____ has lost much of its flexibility that the fishes has
➢Specialized with a shortening of the body
➢9 trunk _____ and a _____
➢Skull is vastly altered – flattened – fewer bones – anterior is better developed while the posterior is much reduced
➢_____ bones and muscles present the typical tetrapod pattern – hip, knee, ankle or shoulder, elbow, wrist

➢Foot is typically five rayed – _____ and the hand is typically four rayed (jointed digits)
➢Two major groups of muscles on any limb: anterior and ventral (protraction and adduction) & posterior and dorsal (retraction and abduction)

Respiration and Vocalization

➢ respiratory surfaces: skin (_____), mouth (_____), and lungs
➢Carbon dioxide mostly diffused across the skin while oxygen is absorbed primarily across the lungs
➢Problem in lung evolution was not development of a good internal surface, but the problem of moving the air
➢_____ breathers – which means that amphibians forcing air into the lungs
➢Male and Female frogs have vocal cords located in the pharynx, but the _____ are much better developed
➢Produce sound by passing air back and forth over the vocal cords between the lungs and a pair of vocal pouches in the floor of the mouth
➢ The males use the vocal pouches as _____ to enhance their mating calls
➢Calls can be used as identifiers

Circulation

➢_____ System
➢_____ Circulation – systemic circulation to the body and a pulmonary circulation to the lungs
➢Frogs hearts have two separate _____ and a single undivided _____
➢Blood from the body (systemic circuit) first enters a large receiving chamber, the sinus venosus, which forces blood into the right atrium
➢The left atrium receives freshly oxygenated blood from the lungs
➢Both atria contract at the same time, driving both left and right atrial blood into the _____
➢Even though the ventricle is undivided the blood remains mostly separated – therefore, when the ventricle contracts, oxygenated pulmonary blood enters the systemic circuit and deoxygenated systemic blood enters the pulmonary circuit – aided by the spiral valve, which divides the systemic and pulmonary flow in the conus arteriosis

Feeding and Digestion

_____ like most other adult amphibians
➢Feed on insects, spiders, worms, slugs, snails, millipedes, and nearly anything else that moves and is small enough to swallow whole
➢They snap at moving prey with _____ tongue which is connected to the front & is free behind
➢Glandular free end of the tongue produces a sticky secretion that adheres to prey
➢When teeth are present, they are to prevent _____ of prey, not for _____
➢The digestive track is relatively short which produces a variety of enzymes for digestion
➢Tadpoles are usually _____ feeding mostly on pond algae, therefore they have a relatively long intestinal tract

Nervous System and Special Senses

➢3 part brain – _____ (sense of smell), _____ (vision), & _____ (hearing and balance)
➢_____ evolved as a means to keep the eyes moist

Reproduction

➢Through _____ (clasping), _____ fertilization occurs
➢As a female lays eggs, the male discharges sperm over the eggs to fertilize them
➢The _____ _____ absorb water and swell
➢Eggs are laid in large masses, usually anchored to vegetation
➢_____ life cycle –aquatic larvae, terrestrial adult

Overview of Amphibians

•Skeleton mostly of _____, with varying numbers of _____; ribs present ome, absent or fused to vertebrae in others; notochord does not persist; exoskeleton absent
ody forms vary greatly
•Limbs usually four (_____), although some are legless; forelimbs present; no true nails or claws; forelimb usually with four digits but sometimes five and sometimes fewer

·Skin _____ & _____ with many glands, some of which may be poison glands; pigment cells common, of considerable variety; no scales except concealed dermal ones
·Mouth usually large with small teeth in upper or both jaws; two nostrils open into anterior part of mouth cavity
·Respiration by _____ (absent in some salamanders), skin and gills in some, either separately or in combination; external gills in larval forms and may persist throughout life in some
·Circulation with _____-chambered heart, two atria and one ventricle, and a double circulation through the heart; skin abundantly supplied with blood vessels
·_____
·_____ sexes; fertilization mostly internal in salamanders and caecilians, moslty external in frog and toads; predominantly oviparous some ovoviviparous or viviparous metamorphosis usually present moderately yolky eggs with jellylike membrane coverings

Environmental Concerns
Conservation Efforts

Reptiles

- _____ include the extinct dinosaurs and today's snakes, lizards, turtles, alligators, and crocodiles.
- Reptiles have _____ within a rib cage; they are covered with _____ at protect them from desiccation and predators.
- Reptiles have _____ and also lay a _____ *egg*, which contains *extraembryonic membranes*, including an _____ that allows the embryo to develop on land.
- Features that distinguish reptiles include:
  - *Usually tetrapods*
  - *Lungs with expandable rib cages*
  - *Shelled, leathery egg*
  - *Dry, scaly skin*
- Fishes, amphibians, and reptiles are _____.(_____)
- Reptiles try to regulate their body temperature by moving to a warmer or cooler location as needed.

The reptilian egg allows reproduction on land

Order Testudines

- Enclosed in shells consisting of a dorsal _____ & a ventral _____
- Jaws are horny _____ instead of teeth
- _____ with internal fertilization – bury eggs
- In some, nest temperature determines _____ of offspring
- Vertebrae and ribs are fused to carapace – can't walk out of shell like in the cartoons
- Tongue is not _____ & Neck is usually _____

Turtles VS Tortoises

Order Squamata

- Suborder Serpentes – snakes - (_____) suborder - No limbs or ear openings
  - Eyes are _____ and immovable & _____
- –Most are non poisonous
  - _____ – eat whole prey
- –Others are poisonous
  - _____ – destroys red blood cells and alters blood clotting
  - _____ – interfers with function of nervous system
- –Most are _____

Order Sphenodonta – Tuatara

- Long living lizard-like creature (just found "thought to be extinct" in New Zealand)
- Well developed eye complete with elements of cornea, lens, and retina buried beneath the _____
- _____ eye can register only changes in light intensity
- Almost identical to its _____ million year old fossil relatives

Order Crocodilia – crocodiles and alligators

- Carnivorous
- _____ chambered heart
- Oviparous
  - Mating = mid April through May
  - Clutch size = _____ eggs
  - Gestation = _____ days
- Incubation temperature effects sex
  - 86 degrees = female
  - 93 degrees = male (IT IS THE _____ FOR TURTLES)

Class Aves

• *Birds* are characterized by the presence of _____, which are modified reptilian scales.

•Birds lay _____ *eggs* rather than the leathery eggs of reptiles.

•Birds are likely closely related to _____ dinosaurs, although this is still under study.

•More than _____ species

Archaeopteryx

•_____ million year old fossil

•From 1861 to 1987 _____ specimens found

•Thought to be transitional between reptiles and modern birds

•Anatomy and Physiology of Birds

•Features of birds are related to the ability to fly.

•Bird forelimbs are modified as _____.

•Bones are _____ & laced with air cavities; the sternum has a _____ to which flight muscles attach.

•A horny _____ replaces teeth.

•Respiration is efficient due to _____ _____.

•Birds have a _____-*chambered heart*, and birds are _____.

•Classification of Birds

•The classification of birds is based on_____& _____ types & to some extent on habitat & behavior.

•_____ extant orders and a few fossil orders

•These features distinguish birds: (6 features)

Reproduction

•More than 90% of birds are _____

•Female typically only _____ ovary develops

•Young are either _____ or _____

-_____ (covered with down) can run or swim and include most water birds

-_____ (helpless and naked)

The Incredible Egg

_____ _____ - an empty space located at the large end of the egg; it is between the inner and outer shell membranes.

_____ - a spiral, rope-like strand that anchors the yolk in the thick egg white. There are two chalazae anchoring each yolk; one on the top and one on the bottom. (The plural of chalaza is chalazae.)

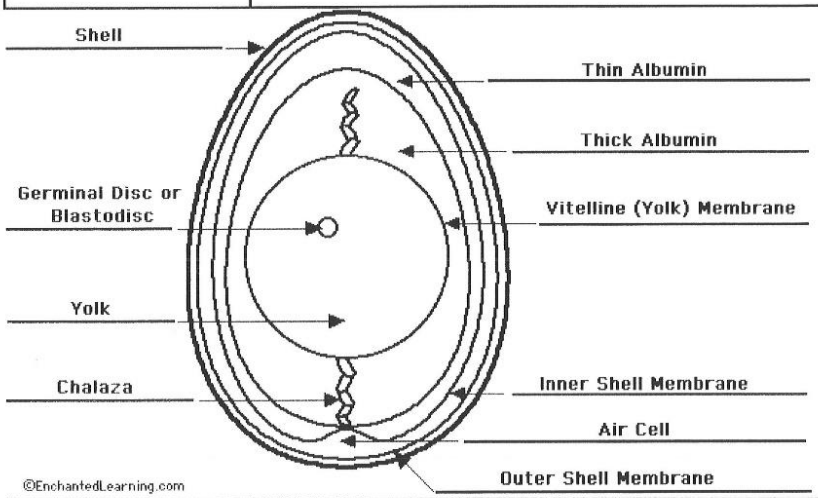
_____ _____ - a small, circular, white spot (2-3 mm across) on the surface of the yolk; it is where the sperm enters the egg. The nucleus of the egg is in the blastodisc.

_____ - the hard, protective coating of the egg. It is semi-permeable; it lets gas exchange occur, but keeps other substances from entering the egg. The shell is made of calcium carbonate.

_____ - the egg white.

_____ - the yellow, inner part of the egg where the embryo will form. The yolk contains the food that will nourish the embryo as it grows.

Order	example
	Cranes, rails, coots, gallinules
	Gulls, plovers, sandpipers, terns
	Woodpeckers, toucans,
	Falcon, eagle, hawk, vulture, buzzard condor
	owls
	Frigatebird, pelicans, boobies
	penguins
	Herons, egrets, storks, ibises, spoonbills, flamingos



Cranes - Order Gruiformes	**Herons & Egrets - Order Ciconiiformes**
Fly with neck outstretched	Fly with recurved neck
Bare red crown	Fully feathered head
Loud, rattling bugle call	Croak call
Long-lived (15-20 yrs)	Short-lived
Monogamous	Change mates
Nest on ground, solitary	Nest in tree, colonial
Lay 1-2 eggs	Lay 4-7 eggs
Parents take chick to food	Parents take food to chick
Young stay with parents 10 months	Parents desert young after fledging (?? months)
Long subadult period (3-8 years)	Breed at 1-2 years

Class Mammalia

•Separated into _____ subclasses, one extinct, other extant

•Second subclass is divided into _____ infraclasses

_____ & _____ are each in their own infraclass

•All placental mammals are in Infraclass _____ with 19 orders

Order Montremata

•Egg-laying (_____) mammals

•Include duck bill _____ and spiny ant eater (_____)

•Duck bill platypus found in _____ & _____

• _____ species of echidna is found in Australia, Tasmania, and New Guinea

•All montremes nourish young with milk

Order Marsupialia

• _____ mammals

•Include opposums, kangaroos, koala, tasmanian devils, wombats, wallaby, and bandicoots

• _____ species with most representatives in Australia and some in Americas

Order Insectivora

•Insect-eating mammals

•Include _____, _____, & _____

• _____ species with small sharp-snouted animals with primitive characteristics

Order Chiroptera

• _____ mammals

_____ species of bats

•Use of _____ and mostly nocturnal

Order Primates

•First in the animal kingdom in _____ with especially large cerebral hemispheres

•Include prosimians, monkeys, apes, humans

• _____ include lemurs, tree shrews, tarsiers, lorises, and pottos (primates restricted to the tropics of the Old World)

•Five digits on both fore and hind limbs

• _____ species

Order Xenarthra

•Either toothless (_____) or with simple peglike teeth (_____ & _____)

• _____ species restricted to South and Central America

•Exception is nine banded armadillo in southern US

Order Lagomorpha

• _____ resembling rodents but with four upper incisors

• _____ species including rabbits, hares, and pikas

Order Rodentia

• _____ mammals

• _____ species including squirrels, rats, and woodchucks

Most _____ of all mammals in numbers and species

•Dentition with two upper and lower chisel-like incisors that grow continually

Order Cetacea

•One of three orders of _____ mammals
•Includes _____ species of whales, dolphins, and porpoises
•Anterior limbs modified into broad _____ with posterior limbs absent
•_____ are single or double blow hole on top of head
•When teeth are present, all alike and lacking _____

Order Carnivora

•_____ mammals
•Includes _____ species of dogs, wolves, cats, bears and weasels
•Some of the most intelligent and strongest of animals
•All with predatory habits
•Teeth especially for _____ _____

Order Pinnipedia

•Second order of _____ mammals
•Includes _____ species of sea lions, seals, sea elephants, and walruses
•Carnivores with limbs modified into _____ for swimming
•All marine; food consists mostly of fish

Order Proboscidea

•Only _____ species remain extant
•Indian elephant with relatively _____ ears
•African elephant with _____ ears

Order Perissodactyla

•_____ hoofed mammals
•Include _____ species of horses, asses, zebras, tapirs, and rhinoceroses
•All herbivorous with teeth adapted for _____
•Often referred to as _____

Order Artiodactyla

•_____ hoofed mammals
•Includes _____ species of swine, camels, deer, hippopotamuses, giraffes, antelopes, cattle, proghorn, sheep, and goats
•Many with _____
•Many are _____ (partitioned stomachs)
•Also referred to as _____

The Difference Between Antlers and Horns

•_____, on members of the deer family, are grown as an extension of the animal's skull. They are true bone and are a single structure They are generally found only on _____. Antlers are shed and regrown each year.

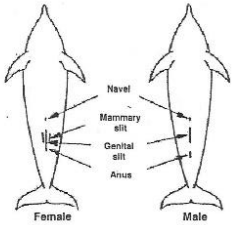
•_____, found on pronghorn, bighorn sheep, bison, and many other bovine, are two-part structures. An interior of bone (also an extension of the skull) is covered by an exterior sheath grown by specialized hair follicles, as are your fingernails. In fact, your fingernails and the exterior sheath of horns are made of very similar materials. Horns are _____ _____ and continue to grow throughout the animal's life. The exception to this rule is the _____ which sheds and regrows its horn sheath each year.

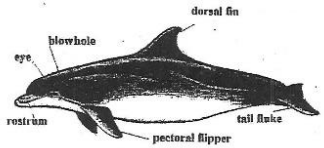
•http://www.nps.gov/archive/yell/kidstuff/AHgame/index.htm

DOLPHINS



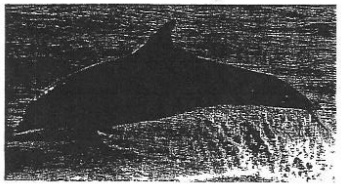
The anatomy of a dolphin





DID YOU KNOW?

- The dolphin family has 39 members including the largest species of dolphin, the Killer Whale!
- The bottlenose dolphin can grow 7-10 feet in length and weigh between 300-600 pounds.
- Dolphins can swim as fast as 30 mph in short bursts of speed. Generally, they swim 5-7 mph.
- Bottlenose dolphins have between 80-100 conically shaped teeth.
- When dolphins exhale, they exchange about 80% of the air in their lungs whereas humans exchange only 20%.



Is a dolphin a MAMMAL or FISH??? Visit our Museum to find out!

- Manatee history
- The Manatee has roamed the earth for over _____ years.
- The Manatee evolved from _____ & live _____.
- The Manatee can live up to the age of 50 to 60 years old.
- The Manatee eats on _____ & can go through ____ sets of teeth
- There are _____ species of Manatees:
  1. **West Indian Manatee** lives primarily in _____& visit _____. This Manatee 13ft & weigh _____
     - The gestation period is about _____ months & young remain with mom _____
  2. The **West African Manatee** Habitats in _____. Very little is known about the West African Manatee. Very few studies have been made on this species.
  3. The **Amazonian Manatee**: smooth skin, no nails on flippers. Found in the fresh waters of the Amazon River and tributaries. Feeds on fresh water vegetation & under pressure from _____
  4. **The Dugong Manatee;** smooth skin, notched tail fluke, without nails on flippers, habitats on marine grasses. Found in the Indo-Pacific region, Asia and Australia areas. Hunted for food by native people. Feeds on marine grasses and the mature Dugong can still grow tusks like an elephant.
  5. The Steller Sea Cow; dark gray, heavy textured skin, forked tail fluke, toothless. Up to 30 ft in length. Weight: 3 ½ tons. Formerly found in the arctic waters of the Bering Strait.

Hunted into _____ within 27 years of it's discovery in 1741.

- MANATEE AWARENESS
- HABITAT

Due to the economy and fuel prices, numerous boaters have been forced into the local waters where the manatees live year round. With more boats on the water, it makes it difficult for the manatees to take shelter. Unfortunately, Manatee deaths have increased in the year 2008 compared to previous years.

High speed impacts from boats is the leading problem in Manatee mortality.

It's generally not the propellers that kill them, it's the impact of the boat hull while up on plane.

When operating a boat near a Manatee area you should reduce your speed and be very alert to where a Manatee might be.

Some Manatees are killed from digestion of fishing line and other small items left in the water from fisherman and boaters.

The fines and penalties for harassing a Manatee are very stiff.

There is no pinching, poking, probing, or riding a Manatee at any time.

Only use 1 hand to have an interaction.

Do not pursue the manatee, let them come to you.

Do not go into the manatee sanctuary, this is where the manatees go and sleep or to get away from boats and people.

- MANATEE LAWS

Never feed or water a Manatee. Never separate a mom and her calf. Always allow the Manatee to leave if it wants to.

If these laws are broken and you are caught by the US Fish and Wildlife Commission, the fines and penalties could be up to $10,000.00 and/or one year in jail. This a federal offense.

Name: Class: Date:

#1 A hollow tube that develops into spinal cord & brain with vertebrates is
A) dorsal nerve cord
B) notochord
C) phayngeal pouches
D) post-anal tail

#2 Acorn worms are included within Subphylum ....
A) Hemichordata
B) Urochordata
C) Cephalochordata
D) Vertebrata

#3 The tunicates and sea squirts are classified within Subphylum....
a) Cephalochordata
b) Urochordata
c) Hemichordata
d) Vertebrata

#4 Body system that includes heart, vessels, arteries and veins is ....
A) excretory system
B) endocrine system
C) circulatory system
D) respiratory system

#5 Body system that aids in locomotion, connects to the skeletal system is ...
A) nervous system
B) integumentary system
C) endocrine system
D) muscular system

#6 The characteristics of phylum Chordata that develops into gill chambers and gills for aquatic chordates is
A) dorsal nerve cord
B) notochord
C) post-anal tail
D) pharyngeal pouches

#7 Body system that includes organs to remove nitrogenous wastes (urea) is ...
A) endocrine
B) excretory
C) circulatory
D) reproductive

#8 Chordate characteristics include all EXCEPT
A. radial symmetry
B. three germ layers
C. well developed coelom
D. complete digestive tract

#9 Controversial group of animals with many characteristics **similar** to echinoderms is Subphylum
A) Hemichordata
B) Urochordata
C) Cephalochordata
D) Vertebrata

#10 Lancelets are classified within Subphylum ...
A) Hemichordata
B) Urochordata
C) Cephalochordata
D) Vertebrata

#11 The character within Phylum Chordata that develops into gill chambers & gills for aquatic chordates is ...
A) dorsal nerve cord
B) notochord
C) post-anal tail
D) pharyngeal pouches

#12 Scales, feathers, and sweat glands are all part of the _____ system.
A) excretory
B) endocrine
C) integumentary
D) nervous

#13 All are invertebrate chordates EXCEPT
A) fish
B) lancelets
C) tunicates
D) pterobranchs

#14 Largest subphylum,containing the MOST species, within Phylum Chordata is Subphylum ...
A) Hemichordata
B) Urochordata
C) Vertebrata
D) Cephalochordata

#15 Respiration of Chordates is accomplished by all EXCEPT
A) siphon
B) gills
C) lungs
D) integument

Chordata deliberate practice F 18 - (ID# 18285163) - Page 1

#16 The anterior end of the dorsal hollow nerve cord develops into the .....
A. tail
B. brain
C. endocrine system
D. digestive system

#17 All are vertebrates EXCEPT

A) fish
B) amphibians
C) acorn worms
D) birds

#18 Original name for lancelets is ...

A) sea vases
B) amphioxus
C) pterobranches
D) acorn worms

#19 The Subphylum that retains no chordate hallmarks in adult form is ...
A) Urochordata
B) Cephalochordata
C) Vertebrata
D) Hemichordata

#20 The Genus name for lancelet is ...

A) Brachiostoma
B) Halocynthia
C) Amphioxus
D) Pterobranchs

#21 Other names for tunicates include all EXCEPT
A. sea squirts
B. salps
C. pyrosomes
D. hemichordates

#22 Phylum Chordata may be divided into the Subphyla including all EXCEPT
A. Tunicata
B. Cephalochordata
C. Hemichordata
D. Vertebrata

#23 In order to be included in Phylum Chordata, the four main characteristics MUST be present
A) during entire lifetime
B) at one time during development
C) at beginning of development
D) by adult stage

#24 Pharyngeal pouches with terrestrial chordates later develop into all EXCEPT
A) gills
B) inner ear
C) jaws
D) tonsils

#25 Characteristics of Tunicates include all EXCEPT

A) stolons
B) incurrent siphon
C) chordate characteristics maintained into adulthood
D) tunic

Name: Class: Date:

#1 Almost all fish have 3 common features: they are cold-blooded, have a backbone, & possess ...
a. lungs
b. gills
c. operculum
d. claspers

#2 Characteristics of hagfish include all EXCEPT
A) sensory tentacles around mouth
B) separate sexes
C) mouth with two rows of teeth
D) single nostril at tip of snout

#3 Characteristics of lamprey include all EXCEPT
A) sex organs separate
B) single nostril on top of head
C) oral disc with teeth
D) internal fertilization

#4 The study of fish is called ...

A. entomology
B. ichthyology
C. herpetology
D. ornithology

#5 Lamprey's classification include all EXCEPT

A. Phylum Animalia
B. Subphylum Vertebrata
C. Superclass Agnatha
D. Class Cephalaspidomorphi

#6 The (Super)Class Agnatha is composed of two groups: lampreys and _____.
a. rays
b. whales
c. starfish
d. hagfish

#7 Characteristics of Agnathans include all EXCEPT
A. cartilaginous skeleton
B. gill slits
C. paired fins
D. spawning

#8 The _____ fish are the most primitive fish.
a. ray finned
b. jaws, cartilagous skeleton
c. jawless, cartilagous
d. extant

#9 ___ is the tough, flexible, rod like structure that runs along the back of a chordate.
a) gill slits
b) fin
c) dorsal nerve cord
d) notochord

#10 North Atlantic exotic Sea Lampreys are ___.

a) autotrophs
b) parasites
c) reptiles
d) anaerobes

#11 Characteristic of most fishes include all EXCEPT
a) Respiration using gills
b) Exchange of gases through thin, moist skin
c) Scales
d) Two chambered heart

#12 Skeletons of sharks, lampreys, and their relatives are made up of ___.
a) cartilage
b) bone
c) scales
d) calcium

#13 All fish have a ___ chambered heart.

a) one
b) two
c) three
d) four

#14 Lampreys may secrete ___ to prevent blood flow from clotting.
a) hirudin
b) anticoagulant
c) lipids
d) red blood cells

#15 The ability to move to freshwater systems from marine for reproduction is ....
A. catadromous
B. anadromous
C. amphibian
D. nonexistent

#16 An animal whose body temperature changes with the surrounding temperatures is called ...
a) An endotherm
b) A mesotherm
c) An ectotherm
d) An echinoderm

#17 Larva form of lamprey is called

A) bipinnaria
B) ammocoete
C) agnatha
D) hagfish

#18 A fish that's classified within (Super)Class Agnatha and a marine scavenger is called
A) lamprey
B) ammocoete
C) hagfish
D) shark

#19 Type of fish that may tie itself in a knot for extra leverage in feeding is the ...
A) lamprey
B) lancelet
C) hagfish
D) skate

#20 Hermphorditic fish classified within (Super)Class Agnatha include the
A) hagfish
B) lamprey
C) lancelet
D) leech

#21 Number of exotic sea lamprey in the Great Lakes region decreased lately due to all EXCEPT
A) depletion of food supply
B) larvicide
C) sterilization of males
D) closing of Welland Canal

#22 Lamprey travel to ____ in order to spawn.

A) hydrothermal vents
B) barrier islands
C) sea
D) freshwater

#23 Hagfish are classified within (Super)Class

A) Myxini
B) Cephalaspidomorphi
C) Chordata
D) Vertebrata

#24 Degenerative eyes, almost blind, are found with ...
A) sharks
B) lamprey
C) lancelets
D) hagfish

#25 Similarities between hagfish and exotic sea lamprey include ...
A) number of gill slits
B) method of feeding
C) larval stage
D) external fertilization

Name: Class: Date:

#1 Class Agnatha include

A) rays
B) bass
C) catfish
D) lamprey

#2 Characteristics of Class Agnatha include all EXCEPT

A) skeleton of bone
B) jawless
C) no paired fins
D) gill slits

#3 Characteristics of hagfish include all BUT

A) sensory tentacles around mouth
B) separate sexes
C) mouth with two rows of teeth
D) single nostril at tip of snout

#4 All are invertebrate chordates BUT

A) fish
B) lancelets
C) tunicates
D) pterobranchs

#5 Class Agnatha include

A) rays
B) bass
C) catfish
D) lamprey

#6 Characteristics of lamprey include all BUT

A) sex organs separate
B) single nostril on top of head
C) oral disc with teeth
D) internal fertilization

#7 Sharks and rays belong to which group of fish?

a) bony
b) jawless
c) cartilaginous
d) terrestrial

#8 What structure allows for water to pass over gills when mouth is closed?

a. operculum
b. gill slits
c. spiracles
d. spiral valve

#9 Members of the class Chondrichthyes may include ....

a. whale shark
b. lamprey
c. whale
d. lungfish

#10 Chondrichthyes have skeletons composed of _____.

a. rays
b. bone
c. cartilage
d. scales

#11 How many fins are paired with cartilaginous fish?

a. 1
b. 2
c. 3
d. 4

#12 Derived or modern sharks have characteristics including all EXCEPT

a. five gill slits
b. no spiracle
c. cartilaginous skeleton
d. defensive spines

#13 Features of placoid scales include all EXCEPT

A) resemble teeth
B) reduces turbulence
C) creates tough leather-like layer
D) camouflage

#14 Fin labels found with chondrichthyes include all EXCEPT

A) pelvic
B) pectoral
C) lateral
D) dorsal

#15 Great White sharks are included within the Order _____.

a.Order Carcharhiniformes
b.Order Lamniformes
c.Order Squaliformes
d.Order Rajiformes

#16 Characteristics of rays include all EXCEPT
A) gill openings on underside
B) enlarged pectoral fins
C) no spiracles
D) extended whip-like tail

#17 The appendage utilized in reproduction with elasmobranchs is called the ...
a) spiracle
b) clasper
c) cloaca
d) ampullae of Lorenzini

#18 Type of fish that possesses both bony & cartilaginous type of characteristics is ...
a. ratfish
b. catfish
c. lungfish
d. skate

#19 If a shark did not continually move forward it would ____.
a) sink to the bottom
b) fall asleep
c) could not eat
d) all of the above

#20 Hammerhead sharks are included within the Order _____.
a.Order Carcharhiniformes
b.Order Lamniformes
c.Order Squaliformes
d.Order Rajiformes

#21 Row of special sensory cells used to detect physical movement in the water is called ...
a. lateral line
b. ampullae of Lorenzini
c. operculum
d. spiracles

#22 All are found in Subclass Elasmobranchii EXCEPT
A) chimearas
B) rays
C) skates
D) sharks

#23 Characteristics of Class Chondrichthyes include all EXCEPT
A) jaws
B) gill slits
C) skeleton of cartilage
D) all oviparous

#24 Largest subphylum of Phylum Chordata is Subphylum ...
A) Hemichordata
B) Urochordata
C) Vertebrata
D) Cephalochordata

#25 **Advantages of cartilage backbone include all EXCEPT**

A. lighter than bone
B. better flexibility
C. increased speed
D. less repair time

Name: Class: Date:

#1 Phylum Hemichordata is a controversial group more closely related to _____ due to similarities in larval forms.
A.) Arthropods
B.)Crustaceans
C.) Echinoderms
D.) Mollusks

#2 Unlike the ___ and the ___, the vertebrates have a vertebral column.
a) Agnatha, Chondrichthyes
b) Osteichthyes, Aves
c) Urochordata, Cephalochordata
d) lampreys and hagfish

#3 Cartilaginous fishes, sharks and rays are classified within Class
A) Agnatha
B) Osteichthyes
C) Chondrichthyes
D) Aves

#4 The tunicates and sea squirts are members of one of the Chordate Subphylum known as ....
a) Cephalochordata
b) Urochordata
c) Hemichordata
d) Vertebrata

#5 Other names for Chimaeras include all EXCEPT
A) ratfish
B) rabbitfish
C) ghostfish
D) dogfish

#6 Parasites that fed on a variety of fish species causing damage to the fishing industry in the Great Lakes are ...
A.)Hagfish
B.) Sharks
C.) Rays
D.) Lampreys

#7 Characteristics of Tunicates include all EXCEPT
A) stolons
B) incurrent siphon
C) ALL chordate characteristics maintained into adulthood
D) tunic

#8 Largest Subphylum of Phylum Chordata is Subphylum ...
A) Hemichordata
B) Urochordata
C) Vertebrata
D) Cephalochordata

#9 All are invertebrate chordates EXCEPT
A) fish
B) lancelets
C) tunicates
D) pterobranchs

#10 Characteristics of hagfish include all EXCEPT
A) sensory tentacles around mouth
B) invertebrate
C) mouth with two rows of teeth
D) single nostril at tip of snout

#11 Characteristics of lamprey include all EXCEPT
A) asexual reproduction
B) single nostril on top of head
C) oral disc with teeth
D) external fertilization

#12 Characteristics of Class Agnatha include all EXCEPT
A) scales
B) jawless
C) no paired fins
D) gill slits

#13 Superclass Agnatha include ...
A) rays
B) bass
C) catfish
D) lamprey

#14 Allows for extended time of absorption of nutrients in the digestive tract is the .....
a. operculum
b. gill slits
c. spiracles
d. spiral valve

#15 Row of special sensory cells used to detect electrical currents in the water is called ...
a. lateral line
b. ampullae of Lorenzenii
c. operculum
d. spiracles

#16 All fish have a ___ chambered heart.

a) one
b) two
c) three
d) four

#17 In Elasmobranchs, ___ secrete high concentrations of salt to assist osmoregulators...
a. spleen
b. kidney
c. rectal gland
d. intestine

#18 Characteristics of rays include all EXCEPT
A) asexual reproduction
B) enlarged pectoral fins
C) spiracles
D) extended whip-like tail

#19 The sense of ___ comprises approximately two-thirds of a sharks brain.

a) hearing
b) sight
c) smell
d) touch

#20 Elasmobranch osmoregulators, ensure water and salt are balanced within body are ...
a. rectal gland
b. liver
c. spleen
d. kidneys

#21 Type of reproduction in which embryo gets nutrients from mother via umbical cord is ...
a) viviparous
b) oviparous
c) oviviparous
d) asexual

#22 Shark eggs ___.

a) are nonexistant
b) are extinct
c) are fertilized internally
d) are fertilized externally

#23 Type of reproduction that results with a mermaid's purse is ...
a. viviparous
b. oviviparous
c. oviparous
d. asexual

#24 Buoyancy in sharks is regulated by

A) swim bladder
B) speed it swims
C) oil in liver
D) type of scales

#25 Characteristics of Class Chondrichthyes include all EXCEPT
A) jaws
B) gill slits
C) skeleton of cartilage
D) no scales

Name: Class: Date:

#1 What could NOT be the classification of a jawless fish?
A.)Superclass Agnatha
B.) Class Cephalaspidomorphi
C.) Class Chondrichthyes
D.)Class Myxini

#2 Subphylum Hemichordata is a controversial group because some zoologists believe they are more closely related to _____ due to similarities in larval forms.
A.) Arthropods
B.)Crustaceans
C.) Echinoderms
D.) Mollusks

#3 In order to be included in Phylum Chordata, the four main characteristics MUST be present
A) during entire lifetime
B) at one time during development
C) at beginning of development
D) by adult stage

#4 Which of the following is NOT one of the hallmark characteristics of a chordate?
A.) Pharyngeal pouches
B.) Post-anal tail
C.) Highly developed sensory organs
D.) Dorsal nerve cord

#5 Which organism would be included in Subphylum Cephalochordata?
A.) Acorn worms
B.) Pterochranchs
C.) Lancelets
D.) Tunicates

#6 These organisms parasitize a variety of fish species causing serious damage to the fishing industry in areas such as the Great Lakes.
A.)Hagfish
B.) Sharks
C.) Rays
D.) Lampreys

#7 The study of fish is called ...
A. entomology
B. ichthyology
C. herpetology
D. ornithology

#8 Other names for tunicates include all EXCEPT
A. sea squirts
B. salps
C. pyrosomes
D. hemichordates

#9 The anterior end of the dorsal hollow nerve cord develops into the .....
A. tail
B. brain
C. endocrine system
D. digestive system

#10 Ratfish, rabbitfish, spookfish, and ghostfish are suggestive names for what member of Class Chondrichthyes?
A.) Chimaeras
B.)Ray
C.)Shark
D.) Skate

#11 Which organism secretes a mucosal covering as a defense mechanism?
A.) Acorn worm
B.) Hagfish
C.) Lamprey
D.) Lancelet

#12 All are members of Subclass Elasmobranchii EXCEPT:
A.) Chimaeras
B.) Rays
C.) Sharks
D.) Skates

#13 The ability to move to freshwater systems from marine for reproduction is ....
A. catadromous
B. anadromous
C. amphibian
D. nonexistent

#14 Sharks' senses include all EXCEPT ...
a) emotional
b) sight
c) hearing
d) electrical

#15 Lampreys may secrete ___ to prevent blood flow from clotting.
a) hirudin
b) anticoagulant
c) lipids
d) red blood cells

#16 Which organism would be included in Subphylum Urochordata (Tunicata)?
A.) Acorn worms
B.) Pterochranchs
C.) Lancelets
D.) Tunicates

#17 Characteristics of Tunicates include all EXCEPT
A) stolons
B) incurrent siphon
C) ALL chordate characteristics maintained into adulthood
D) tunic

#18 Pharyngeal pouches later develop into all EXCEPT ____ in terrestrial chordates.
A) gills
B) inner ear
C) jaws
D) tonsils

#19 Similarities between hagfish and exotic sea lamprey include ...
A) number of gill slits
B) method of feeding
C) larval stage
D) external fertilization

#20 The type of reproduction in which embryo gets nutrients from mother via umbical cord is called ...
a) viviparous
b) oviparous
c) oviviparous
d) asexual

#21 Type of fish that may tie itself in a knot for extra leverage in feeding is the ...
A) lamprey
B) lancelet
C) hagfish
D) skate

#22 Features of placoid scales include all EXCEPT
A) resemble teeth
B) reduces turbulence
C) creates tough leather-like layer
D) camouflage

#23 The appendage utilized in reproduction with elasmobranchs is called the ...
a) spiracle
b) clasper
c) cloaca
d) ampullae of Lorenzini

#24 If a shark did not continually move forward it would ___.
a) sink to the bottom
b) fall asleep
c) could not eat
d) all of the above

#25 Largest subphylum of Phylum Chordata is subphylum
A) Hemichordata
B) Urochordata
C) Vertebrata
D) Cephalochordata

#26 All are invertebrate chordates EXCEPT
A) sharks
B) lancelets
C) tunicates
D) pterobranchs

#27 Characteristics of Class Agnatha include all EXCEPT
A) skeleton of bone
B) jawless
C) no paired fins
D) gill slits

#28 Class Agnatha include ...
a) rays
b) bass
c) catfish
d) lamprey

#29 Characteristics of Class Chondrichthyes include all EXCEPT
A) jaws
B) gill slits
C) skeleton of cartilage
D) all oviparous

#30 Buoyancy in sharks is regulated by
A) swim bladder
B) speed it swims
C) oil in liver
D) type of scales

#31 Row of special sensory cells used to detect movement in the water is called ...
a. lateral line
b. ampullae of Lorenzini
c. operculum
d. spiracles

#32 In cartilagous fish, secretions of high salt concentrations come from ...
a. spleen
b. kidney
c. rectal gland
d. intestine

#33 Type of fish that possesses both bony & cartilaginous type of characteristics is ...
a. ratfish
b. catfish
c. lungfish
d. skate

#34 What structure allows for water to pass over gills when mouth is closed?
a. operculum
b. gill slits
c. spiracles
d. spiral valve

#35 Characteristics of rays include all EXCEPT

A) gill openings on underside
B) enlarged pectoral fins
C) no spiracles
D) extended whip-like tail

#36 **Advantages of cartilage backbone include all EXCEPT**

A. lighter than bone
B. better flexibility
C. increased speed
D. less repair time

#37 Temporarily stores bile from liver is the ...
a. spleen
b. cloaca
c. rectal gland
d. gallbladder

#38 All fish have a ___ chambered heart.

a) one
b) two
c) three
d) four

#39 Characteristics of Class Chondrichthyes include all EXCEPT

A) jaws
B) gill slits
C) skeleton of cartilage
D) no scales

#40 Number of lamprey in the Great Lakes region decreased lately due to all BUT

A) depletion of food supply
B) larvicide
C) sterilization of males
D) closing of Welland Canal

#41 Allows for extended time of absorption of nutrients in the digestive tract is the .....
a. operculum
b. gill slits
c. spiracles
d. spiral valve

#42 _____ fish are members of the Class Chondrichthyes.

a. whale shark
b. lamprey
c. whale
d. lungfish

#43 Row of special sensory cells used to detect electrical currents in the water is called ...
a. lateral line
b. ampullae of Lorenzini
c. operculum
d. spiracles

#44 The organ that secretes enzymes to intestine is the ...
a. gall bladder
b. spleen
c. pancreas
d. swim bladder

#45 Dissection Part I

Pectoral Fin is

A) A
B) B
C) C
D) D
E) E

#46

Dissection
Part I

Caudal Fin is

A) A
B) B
C) C
D) D
E) E

#47

Dissection
Part II
Claspers are

A) A
B) B
C) C

#48

Dissection
Part II

The part labeled C is called the

A) anus
B) rectum
C) cloaca

#49

Dissection
Part III
The liver is

A) A
B) B
C) C
D) D
E) E
F) F

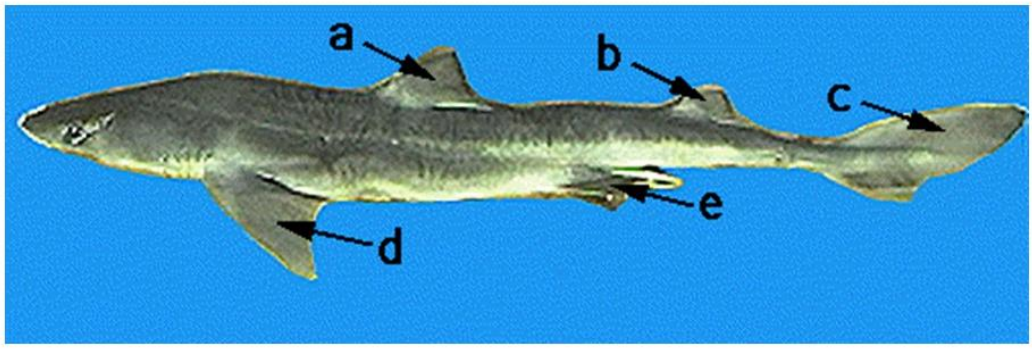
#50

Dissection
Part III
The spleen

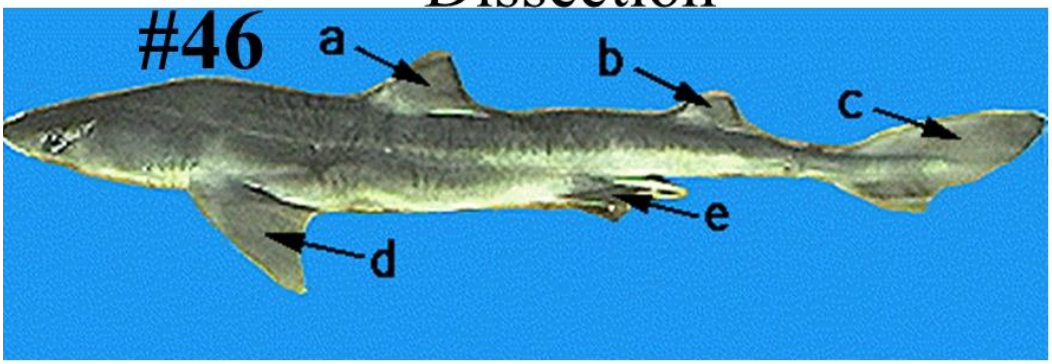
A) A
B) B
C) C
D) D
E) E
F) F

Dissection

#45 Part I

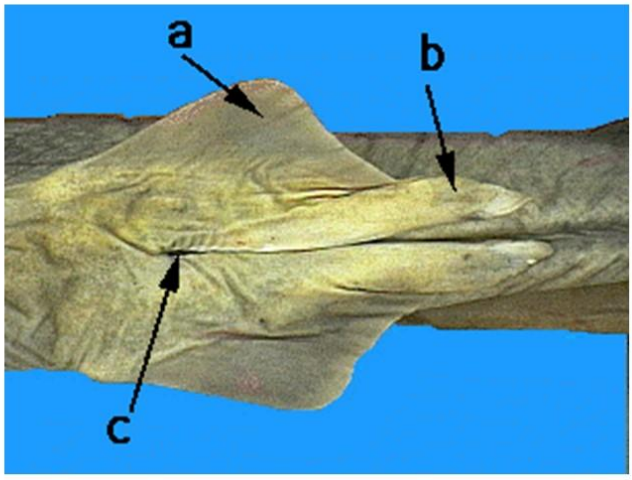


Dissection



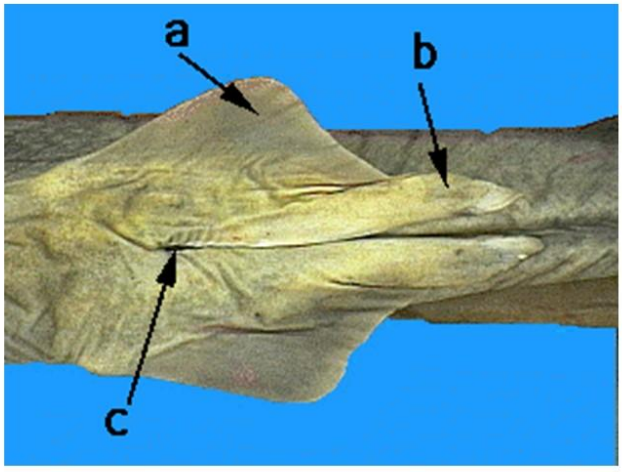
#47

Dissection
Part II

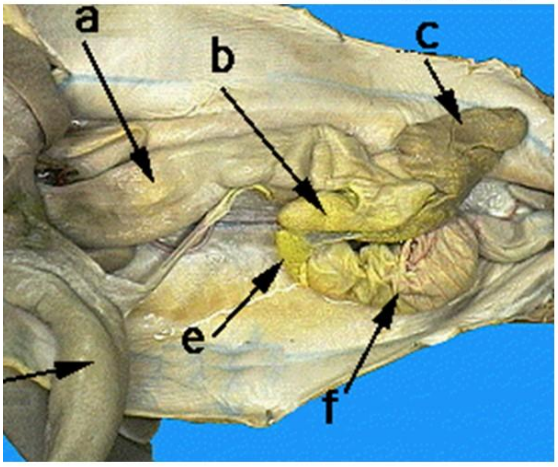


#48

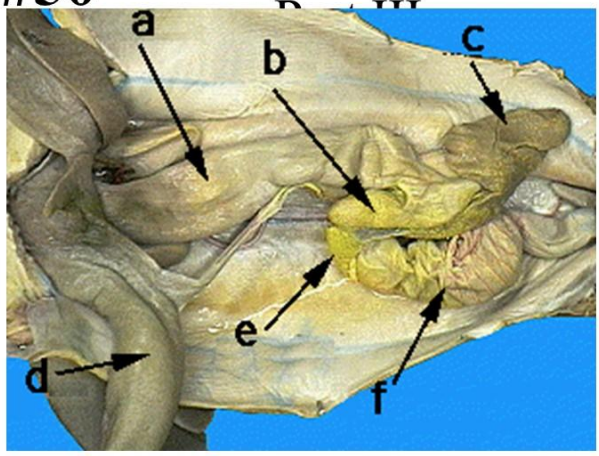
Dissection
Part II



#49 Dissection Part III

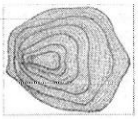


#50 Dissection



Name: Class: Date:

#1 Which type of scale is shown?
a) cycloid
b) ctenoid
c) placoid
d) ganoid



#2 Bony fish have _____ that help them float in water at different levels.
a. oily liver
b. swim bladders
c. strong fins
d. constant movement

#3 Ray-finned fish are classified with Class ...
A. Agnatha
B. Chondrichthyes
C. Elasmobranchii
D. Actinopteryfii

#4 Which type of scale is shown?
a) cycloid
b) ctenoid
c) placoid
d) ganoid

#5 Chondrosteans include all EXCEPT
a. bichirs
b. sturgeons
c. gars
d. paddlefish

#6 Advanced caudal fins are described as ...
A. heterocercal
B. homocercal
C. cycloid
D. ganoid

#7 Which type of scale is shown?
a) cycloid
b) ctenoid
c) placoid
d) ganoid

#8 Class Osteichthyes will include all examples EXCEPT
a. eels
b. bass
c. stingray
d. oarfish

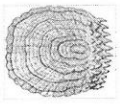
#9 External fertilization in bony fishes is also known as ___.
a) metamorphosis
b) spawning
c) budding
d) regeneration

#10 The kidney of a trout ___.
a) produces enzymes
b) produces uric acid crystals
c) maintains proper osmotic balance
d) aids in digestion

#11 Which of the following support a fishes fins?
a) gills
b) lateral line systems
c) scales
d) rays or spines

#12 Osteichthyes have a ____ chambered heart.
A. one
B. two
C. three
D. four

#13 Which type of scale is shown?
a) cycloid
b) ctenoid
c) placoid
d) ganoid



#14 Pouches that increase the surface area for digestion are called
A) liver
B) gall bladder
C) kidney
D) pyloric caeca

#15 Half of all vertebrates are ...
A) chondrichthyes
B) teleosts
C) lungfish
D) lobe-finned fish

#16 The coelacanth is an example of a

A) lungfish
B) ray-finned fish
C) lobe-finned fish
D) flat fish

#17 The plate that covers the gills is called the

A) swim bladder
B) cerebrum
C) gill rakers
D) operculum

#18 Buoyancy with bony fish is accomplished by ...

A) large livers
B) swim bladders
C) operculum
D) pyloric caeca

#19 Bony fish typically practice _____ fertilization.

A) internal
B) external
C) asexual
D) partial

#20 All are bony fish EXCEPT

A) eel
B) sea horse
C) catfish
D) chimaera

#21 Difference between male and female reproductive systems is ...

A) location
B) number of gonads
C) size
D) nonexistant

#22 Type of primitive fish that possesses ganoid type of scales includes ....

A) sturgeon
B) lobe-finned fish
C) lungfish
D) eel

#23 A determinant of a fish's age is by ...

A) size of fish
B) number of fins
C) color of fins
D) growth rings in scales

#24 Even though the kidneys remove wastes, most of a bony fishes' ammonia is released by way of

A) gills
B) liver
C) pyloric caeca
D) gall bladder

#25 **The most powerful sense possessed by many bony fish is ...**

A. hearing
B. smell
C. sight
D. electrical

Name: Class: Date:

#1 There are three classes of fish: jawless, cartilage, and _____.

a. Agnatha
b. Chrondichthyes
c. Osteichthyes
d. Vertebrata

#2 Bony fish have _____ that help them float in water at different levels.
a. oily liver
b. swim bladders
c. strong fins
d. constant movement

#3 A common name for ray finned fishes is ...

A. chondrichthyans
B. teleosts
C. paleoniscids
D. chondrostreans

#4 The gills of a bony fish are protected by a structure called ...
a. gill slits
b. operculum
c. swim bladder
d. peduncle

#5 The structure that supports the caudal fin of a bony fish is called ...
a. operculum
b. peduncle
c. lateral line
d. anal fin

#6 Similarities between bony fish and elasmobranchs include
a. lateral line
b. ampullae of Lorenzini
c. spiracles
d. claspers

#7 The study of fish is called ...
a. teleostology
b. actinopterology
c. herpetology
d. ichthyology

#8 Exotic fish species include all EXCEPT
a. lionfish
b. asian carp
c. sea robin
d. snakehead fish

#9 Lobe-finned fish include

a. flounder
b. bass
c. coelacanth
d. menhaden

#10 Commercial fish that is found in our area include

a. menhaden
b. pinfish
c. spotted sea trout
d. flounder

#11 **Fish may be divided into two distinctive groups based on ...**

A. salinity
B. color
C. depth of habitat
D. size of fish

#12 ___is NOT characteristic of most fishes.
a) Breathing using gills
b) Exchange of gases through thin, moist skin
c) Scales
d) A two chambered heart

#13 The kidney of a trout ____.
a) produces enzymes
b) produces uric acid crystals
c) maintains proper osmotic balance
d) aids in digestion

#14 Local fish that has teeth similar in appearance to humans is...
a. trout
b. redfish
c. sheephead
d. red snapper

#15 Local fish that makes noise with its swim bladder is ...
a. trout
b. croaker
c. flounder
d. red snapper

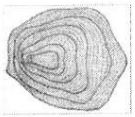
#16 **The BEST strategy evolved by fish to avoid being prey is**

A. spine
B. camouflage
C. sounds
D. small size

#17 Function of the spots found near the caudal fin of redfish is ....
a. age
b. sex
c. camouflage
d. unknown

#18 Local fish that can often be found jumping out of the water...
a. flounder
b. sand seatrout
c. mullet
d. sheephead

#19 Which type of scale is shown?
a) cycloid
b) ctenoid
c) placoid
d) ganoid



#20 Another name for the "cruicifix fish" is ...
a. flounder
b. menhaden
c. gafftopsail catfish
d. pinfish

#21 Another name for the "pogie" fish is ...
A. flounder
B. gafftopsail catfish
C. red snapper
D. menhaden

#22 Similarities between ray finned fish and elasmobranchs include ...
a. swim bladder
b. pyloric ceca
c. two chambered heart
d. bony skeleton

#23 The smaller the peduncle on a bony fish, the ___ it swims

A) faster
B) slower
C) deeper
D) more precise

#24 Type of primitive fish that possesses ganoid type of scales is ...

A) sturgeon
B) lobe-finned fish
C) lungfish
D) eel

#25 A determinant of a fish's age is by ...

A) size of fish
B) number of fins
C) color of fins
D) growth rings in scales

Name: Class: Date:

#1 There are three basic groups of fish: jawless, cartilage, and _____.

a. Agnatha
b. Chrondichthyes
c. Osteichthyes
d. Vertebrata

#2 Class Osteichthyes will include all examples EXCEPT
a. eels
b. bass
c. stingray
d. oarfish

#3 Ray-finned fish are classified with Class ...
A. Agnatha
B. Chondrichthyes
C. Elasmobranchii
D. Actinopteryfii

#4 Bony fish have _____ that help them float in water at different levels.
a. oily liver
b. swim bladders
c. strong fins
d. constant movement

#5 External fertilization in bony fishes is also known as ___.

a) metamorphosis
b) spawning
c) budding
d) regeneration

#6 ___is NOT characteristic of most fishes.

a) Breathing using gills
b) Exchange of gases through thin, moist skin
c) Scales
d) A two chambered heart

#7 The kidney of a trout ____.
a) produces enzymes
b) produces uric acid crystals
c) maintains proper osmotic balance
d) aids in digestion

#8 A common name for ray finned fishes is ...

A. chondrichthyans
B. teleosts
C. paleoniscids
D. chondrostreans

#9 Local fish that makes noise with its swim bladder is ...
a. trout
b. croaker
c. flounder
d. red snapper

#10 Advanced caudal fins are described as ...
A. heterocercal
B. homocercal
C. cycloid
D. ganoid

#11 Chondrosteans include all EXCEPT
a. bichirs
b. sturgeons
c. gars
d. paddlefish

#12 Which of the following support a fishes fins.

a) gills
b) lateral line systems
c) scales
d) rays or spines

#13 The study of fish is called ...
a. teleostology
b. actinopterology
c. herpetology
d. ichthyology

#14 Half of all vertebrates are

A) chondrichthyes
B) telosts
C) lungfish
D) lobe-finned fish

#15 The plate that covers the gills is called the

A) swim bladder
B) cerebrum
C) gill rakers
D) operculum

#16 Differences between male and female reproductive systems is

A) location
B) number of gonads
C) size
D) nonexistant

#17 Function of the spots found near the caudal fin of redfish is ....
a. age
b. sex
c. camouflage
d. unknown

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A) liver
B) gall bladder
C) kidney
D) pyloric caeca

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c. sheephead
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a. swim bladder
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c. two chambered heart
d. bony skeleton

#28 Local fish that can often be found jumping out of the water...
a. flounder
b. sand seatrout
c. mullet
d. sheephead

#29 **The most sensitive sense possessed by fish is**

A. hearing
B. smell
C. sight
D. electrical

#30 **Reproductive methods among fish include all BUT**

A. laying eggs
B. mouth brooding
C. budding
D. carrying young with parent

#31 Pouches that increase the surface area for digestion are called

A) liver
B) gall bladder
C) kidney
D) pyloric caeca

#32 **Fish may be divided into two distinctive groups based on . . .**

A. salinity
B. color
C. depth of habitat
D. size of fish

#33 Type of primitive fish that possesses ganoid type of scales includes ....

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B) lobe-finned fish
C) lungfish
D) eel

#34 Exotic fish species include all EXCEPT

a. lionfish
b. asian carp
c. sea robin
d. snakehead fish

#35 Even though the kidneys remove wastes, most of a bony fishes' ammonia is released by way of

A) gills
B) liver
C) pyloric caeca
D) gall bladder

#36 **The BEST strategy evolved by fish to avoid being prey is**

A. spine
B. camouflage
C. sounds
D. small size

#37 Which type of scale is shown?

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d) ganoid

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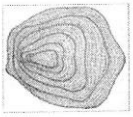


#40 Which type of scale is shown?

a) cycloid
b) ctenoid
c) placoid
d) ganoid

#41 **According to the diagram, which is the caudal fin?**

A. **D.**
B. **E.**
C. **F.**

#42 **According to the diagram, which is the anal fin?**

A. **D.**
B. **E.**
C. **F.**

#43 **According to the diagram, which is the pectoral fin?**

A. **D.**
B. **E.**
C. **F.**

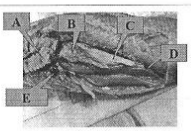
#44 **According to the diagram, which is the pelvic fin?**

A. **D.**
B. **E.**
C. **F.**

#45 **According to the diagram, which is the first dorsal fin?**

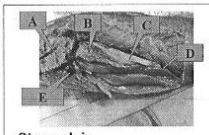
A. **D.**
B. **E.**
C. **F.**

#46



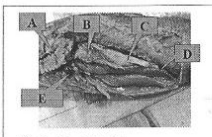
Gills are . . .
F. not labeled

#47



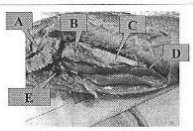
Stomach is . . .
F. not labeled

#48



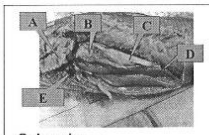
Swim bladder is . . .
F. not labeled

#49

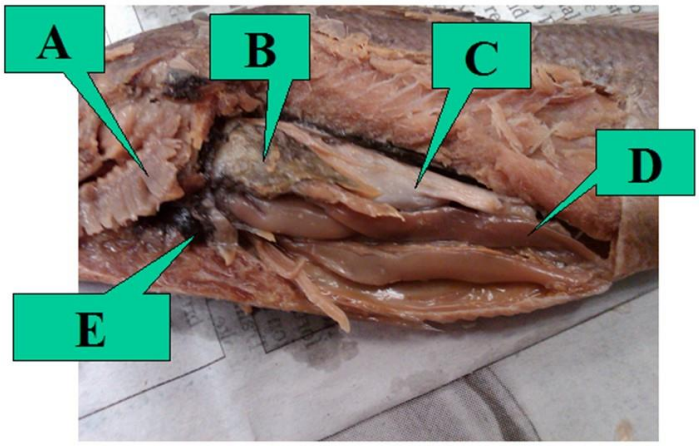


Heart is . . .
F. not labeled

#50



Spleen is . . .
F. not labeled



Name: Class: Date:

#1 Which animal is NOT an amphibian?

a) frog
b) salamander
c) snake
d) toad

#2 Geological time period of fluctuating drought and floods is ....
A. Triassic
B. Cretaceous
C. Devonian
D. Cambrian

#3 Amphibians are often described as ___ (with four limbs).
A. quadrupeds
B. tetrapods
C. ectothermic
D. terrestrial

#4 Animals adapting to land included features including all EXCEPT
A. lungs
B. strong muscles
C. remain in warm climates
D. larger bodies

#5 Frogs are classified within Order ...

A. Gymnophiona
B. Caudata
C. Anura
D. Urodela

#6 An amphibian is often described as ectothermic, meaning ....
a) they are always cold
b) they must live in very hot climates
c) they cannot maintain constant body temperature
d) they must live in very cold climates

#7 Members of Order Caudata include all EXCEPT
A. salamanders
B. sirens
C. caecilians
D. newts

#8 Salamanders are in Order
A. Gymnophiona
B. Caudata
C. Anura
D. Apoda

#9 Some amphibians retain larval characteristics into adulthood, called.....

A. regeneration
B. complete metamorphosis
C. paedomorphosis
D. hemimetabolous

#10 Another name for Order Caudata is Order .....

A. Urodela
B. Anura
C. Apoda
D. Gymnophiona

#11 Form of reproduction when caecilian young eat wall of oviduct is ...
A. oviparous
B. viviparous
C. ovoviviparous
D. asexual

#12 Salamander valuable with scientific study due to ability for limb regeneration is ....
A. mudpuppy
B. siren
C. axolotl
D. caecilian

#13 Ancestors of modern amphibians are theorized to be .....

A. lungfish
B. lobe-finned fish
C. reptiles
D. invertebrates

#14 Fundamental difference between salamanders & newt is ....

A. where they live
B. how they grow
C. what they eat
D. none scientifically

#15 During mating, a male salamander will deposit a packet of sperm called ___.
a. spermatophore
b. testes
c. cloaca
d. oviduct

#16 Largest issue in lung evolution for amphibians is ...
A) good internal surface
B) space within body cavity
C) moving air into lungs
D) oxygen is not diffusable in air

#17 Orders found within Class Amphibia include all EXCEPT
A) Apoda
B) Acaudata
C) Anura
D) Caudata

#18 Amphibians that have slender bodies, front limbs, & no hind limbs are often called ...
a) caecilians
b) salamanders
c) newts
d) sirens

#19 Some amphibians, such as ___, may undergo metamorphic changes under certain environmental conditions.
A) toads
B) caecilians
C) axolotls
D) frogs

#20 Which organism is the transitional animal discovered in 2004 to connect lobe-finned fish with modern amphibians?
A) coelacanth
B) Tiktaalik roseae
C) MS Gopher frog
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#21 The red eft stage is a juvenile form of ...
A) caecilians
B) salamanders
C) newts
D) sirens

#22 **Aquatic siren that is found around here is often called .....**
A. caecilian
B. mud eel
C. newt
D. salamander

#23 Features of limbs with caudates include all EXCEPT
A) right angles
B) possessing six digits
C) approximately same size
D) may be rudimentary or absent

#24 **The largest amphibian will be found in Order ...**
A. Gymnophiona
B. Caudata
C. Anura
D. Apoda

#25 **Salamander that is an example of paedomorphic lifestyle is the ....**
a. axolotl
b. siren
c. mudpuppy
d. mud eel

Name: Class: Date:

#1 Limbless amphibians classified within Order ...

A) Caudata
B) Anura
C) Gymnophiona
D) none of the above

#2 Larval forms of frogs are called ...

a. minnows
b.tadpoles
c. newts
d.salamander

#3 Characteristics of Amphibians .....

A. bony skeleton
B. undergo metamorphosis
C. notochord not in adulthood
D. all of the above

#4 Tail-less amphibians classified within Order ....

A. Gymnophiona
B. Anura
C. Caudata
D. none of the above

#5 Internal fertilization is present with ...

A) Caudata
B) Gymnophiona
C) Anura
D) both A and B

#6 Frogs and toads practice an unique form of sexual reproduction called...

A. viviparous
B. spawning
C. amplexus
D. copulation

#7 Color of amphibians is produced by ...

A) chromatophores
B) mucous
C) keratin
D) ectothermy

#8 All are amphibians EXCEPT

A) salamanders
B) newts
C) lizards
D) frogs

#9 Endangered frog found in Mississippi is the....

A. cane toad
B. Darwin frog
C. mud eel
D. dusky gopher frog

#10 Adaptations to land habitats include all EXCEPT

A) lungs
B) strong muscular and skeletal systems
C) live in warm climates
D) return to water for reproduction purposes

#11 Mudpuppies will undergo metamorphic changes ...

A) under no circumstances
B) after six months of life
C) when water is no longer available
D) when injected with thyroid hormones

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A) full range of motion
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A) males are larger
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C) males have enlarged thumb pads
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#15 Integumentary features of amphibians include all EXCEPT...

A) thin, moist, and loosely attached
B) mucous glands for water proofing
C) nails or claws
D) serous glands for poison

#16 Organ that stores bile produced by the liver is called ...

A) gallbladder
B) pancreas
C) urinary bladder
D) duodenum

#17 Circulation of amphibians include all features EXCEPT

A) open circulatory system
B) two separate atria
C) 1 undivided ventricle
D) sinus venosus

#18 Function of vomerine teeth include ...

A. injection of poison
B. prevent escape of prey
C. display aggression
D. unknown

#19 Types of chromatophores found in amphibians include all EXCEPT

A) chlorophores
B) xanthophores
C) iridophores
D) melanophores

#20 Respiration of amphibians include all EXCEPT

A) integument
B) lungs
C) gills
D) vocal sacs

#21 Similarities among frogs and toads include ...

A) size of hind legs
B) mode of locomotion
C) texture of skin
D) form of sexual reproduction

#22 Features of the amphibian digestive system include all EXCEPT

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C) spleen
D) intestine

#23 Sensory features of amphibians include all EXCEPT

A) typanum
B) nare
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c. nare
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Name: Class: Date:

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A. nares
B. glottis
C. homeothermy
D. hibernation

#43 STATION ONE
Which pin is the fat bodies ?

A) red A
B) red B
C) red C
D) red D
E) red E
F) not pinned

#44 STATION ONE
Which pin can you find the pancreas?

A) red A
B) red B
C) red C
D) red D
E) red E
F) not pinned

#45 STATION ONE
Which pin would you find the glottis?

A) red A
B) red B
C) red C
D) red D
E) red E
F) not pinned

#46

STATION ONE
Which pin is the ventricle?

A) red A
B) red B
C) red C
D) red D
E) red E
F) not pinned

#47

STATION TWO
Which pin is the kidney?

A) white A
B) white B
C) white C
D) white D
E) white E
F) not pinned

#48

STATION TWO
Which pin is the associated with respiratory system?

A) white A
B) white B
C) white C
D) white D
E) white E
F) not pinned

#49

STATION TWO
Which pin is the pancreas?

A) white A
B) white B
C) white C
D) white D
E) white E
F) not pinned

#50

STATION TWO
Which pin is the spleen?

A) white A
B) white B
C) white C
D) white D
E) white E
F) not pinned

Name: Class: Date:

#1 Study of reptiles and some amphibians is called ...
A. anthropology
B. serpentology
C. paleontology
D. herpetology

#2 Characteristics of Class Reptilia include ....

a. respiration by lungs
b. two-chambered heart
c. dry, scaly skin
d. A and C only

#3 Reptiles practice ___ fertilization to prevent dessication of sperm.

a. asexual
b. internal
c. external
d. spawning

#4 The dorsal shell of a turtle is called __.

A. carapace
B. pectoral girdle
C. plastron
D. scutes

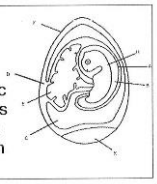
#5 Most reptiles utilize ___ to assist with respiration.

a. scales
b. ribs
c. scutes
d. skin

#6 Scales are formed from ....

a. chromatophores
b. dermis
c. keratin
d. leather

#7 Label E is...



a. yolk sac
b. allantois
c. amnion
d. albumin

#8 Lizards are classified within _____.

a. Order Chelonia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#9 Largest freshwater turtle that is found in our area is ....
a. alligator snapping turtle
b. Pascagoula ridged map turtle
c. Kemp's ridley turtle
d. MS Gopher tortoise

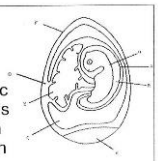
#10 Tortoise are classified within .....

a. Order Chelonia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#11 Ectothermic animals include all EXCEPT
a. fish
b. amphibians
c. birds
d. reptiles

#12 Lizard that is exotic in our area is ....
a. anole
b. brown fence lizard
c. Mediterranean gecko
d. Asian skink

#13 Label A is...



a. yolk sac
b. allantois
c. amnion
d. albumin

#14 Reptiles and amphibians have features in common EXCEPT
a. tetrapods
b. shelled eggs
c. many oviparous
d. ectothermic

#15 Freshwater turtle that is endangered, found in our area is ....
a. alligator snapping turtle
b. Pascagoula ridged map turtle
c. Kemp's ridley turtle
d. MS Gopher tortoise

#16 Some European lizards may develop from unfertilized eggs, called ...

a. prehensile
b. parthenogenesis
c. plastron
d. carapace

#17 Tortoise that is endangered, found in our area is ....
a. alligator snapping turtle
b. Pascagoula ridged map turtle
c. Kemp's ridley turtle
d. MS Gopher tortoise

#18 The shelled egg of a reptile include ....

a. embryo
b. yolk sac
c. amnion sac
d. all of the above

#19 Which are not classified within Suborder Sauria?

a. komodo dragon
b. geckos
c. iguana
d. turtles

#20 Prehensile means to ...

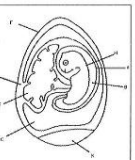
a. live in a primitive time
b. regeneration
c. development of unfertilized egg
d. wrap around limbs

#21 Plates covering a turtle's shell are called ....

a. carapace
b. plastron
c. scutes
d. scales

#22 Sea turtle eggs depend on _____ to determine sex of offspring.
a. time of nesting
b. place of nesting
c. temperature of nest
d. amount of minerals in nest

#23 Label C is...



a. yolk sac
b. allantois
c. amnion
d. albumin

#24 Federally endangered sea turtles include all EXCEPT
a. Leatherback
b. Loggerhead
c. Green
d. Kemp's Ridley

#25 The chameleon can change its color based on
a. mood
b. environment
c. season
d. diet

Name: Class: Date:

#1 Similarities between alligators and crocodiles include all EXCEPT
a. oviparous
b. narrowness of snout
c. carnivores
d. four chambered heart

#2 Examples of non-venomous snakes include ...
a. python
b. king snake
c. boa
d. all of the above

#3 Another name for tuatara is ...
a. prehensile
b. sacral vertebrae
c. sphenodon
d. Jacobson

#4 Snakes are classified within ...
a. Order Rhynchocephalia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#5 Alligators are classified within ...
a. Order Rhynchocephalia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#6 Crocodilians are unique reptiles due to ...
a. oviparity
b. four chambered heart
c. cerebral cortex
d. both B and C

#7 The type of venom that destroys red blood cells and alters blood clotting is
a. uric acid
b. neurotoxin
c. hemotoxin
d. ammonia

#8 The Jacobson's organ found in snakes and lizards function includes ...
a. smell
b. taste
c. hearing
d. see

#9 Movement of snakes include all EXCEPT
a. lateral undulation
b. rectilinear movement
c. concertina movement
d. inch worm

#10 Reptiles that posses urinary bladders include all EXCEPT
a. tuataras
b. turtles
c. snakes
d. lizards

#11 Which temperature ranges will bear female alligator young?
a. lower than 86 F
b. higher than 86 F
c. lower than 93 F
d. higher than 93 F

#12 Some common vipers include all EXCEPT
a. rattlesnake
b. copperhead
c. coral snake
d. water moccasin

#13 Unique heat sensor for snakes is called the ....
a. elapid
b. pit
c. Jacobson's organ
d. sacral vertebrae

#14 How many species are extant classified within Order Rhychocephalia?
a. two
b. ten
c. thousand
d. ten thousand

#15 Features found only with venomous snakes include all EXCEPT
a. single row of ventral tail scales
b. pit
c. elliptical pupils
d. nostril

#16 Similarities between tortoises and turtles include all EXCEPT
A) lungs
B) oviparous
C) beaks
D) type of feet

#17 Movement of snakes in which S shape loops touch ground at two points is called ...
a. lateral undulation
b. rectilinear movement
c. concertina movement
d. sidewinding

#18 Type of reptile that is almost identical to it 200 million year old fossil relatives is the ...
A) alligator
B) gecko
C) tuatara
D) snake

#19 Type of snake whose fangs are fixed and short is ....
a. non-venomous
b. elapids
c. pit vipers
d. vipers

#20 Examples of elapids include all EXCEPT
a. rattlesnake
b. sea snake
c. coral snake
d. cobra

#21 Unique feature found with tuatara....
a. oviparous
b. third eye
c. Jacobson's organ
d. sacral vertebrae

#22 Features found with lizards, but not snakes include all EXCEPT
a. scales
b. limbs
c. ear openings
d. eyelids

#23 The study of reptiles and some amphibians is called ...
a. paleontology
b. serpentology
c. herpetology
d. anthropology

#24 Structure that typically assists reptiles with respiration is ....
a. sacral vertebrae
b. ribs
c. mouth
d. diaphragm

#25 Feature of reptiles that are more "advanced" than amphibians include all EXCEPT
a. respiration
b. excretory
c. nervous
d. digestion

Name: Class: Date:

#1 Characteristics of Class Reptilia include ....

a. respiration by lungs
b. two-chambered heart
c. dry, scaly skin
d. A and C only

#2 Ectothermic animals include all EXCEPT
a. fish
b. amphibians
c. birds
d. reptiles

#3 Scales are formed from ....

a. chromatophores
b. dermis
c. keratin
d. leather

#4 Reptiles and amphibians have features in common EXCEPT
a. tetrapods
b. shelled eggs
c. many oviparous
d. ectothermic

#5 Most reptiles utilize ___ to assist with respiration.

a. scales
b. ribs
c. scutes
d. skin

#6 Study of reptiles and some amphibians is called ...
A. anthropology
B. serpentology
C. paleontology
D. herpetology

#7 I argest freshwater turtle that is found in our area is ....
a. alligator snapping turtle
b. Pascagoula ridged map turtle
c. Kemp's ridley turtle
d. MS Gopher tortoise

#8 Lizard that is exotic in our area is ....
a. anole
b. brown fence lizard
c. Mediterranean gecko
d. Asian skink

#9 Freshwater turtle that is endangered, found in our area is ....
a. alligator snapping turtle
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c. Kemp's ridley turtle
d. MS Gopher tortoise

#10 Reptiles practice ___ fertilization to prevent dessication of sperm.

a. asexual
b. internal
c. external
d. spawning

#11 Tortoise that is endangered, found in our area is ....
a. alligator snapping turtle
b. Pascagoula ridged map turtle
c. Kemp's ridley turtle
d. MS Gopher tortoise

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a. Leatherback
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c. boa
d. all of the above

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B) oviparous
C) beaks
D) type of feet

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B) gecko
C) tuatara
D) snake

#19 Unique feature found with tuatara....
a. oviparous
b. third eye
c. Jacobson's organ
d. sacral vertebrae

#20 Tortoise are classified within .....
a. Order Chelonia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#21 Lizards are classified within _____.
a. Order Chelonia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#22 Snakes are classified within ...
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b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

#23 Alligators are classified within ...
a. Order Rhynchocephalia
b. Suborder Serpentes
c. Order Crocodilia
d. Suborder Sauria

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c. thousand
d. ten thousand

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c. elliptical pupils
d. nostril

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d. ammonia

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b. taste
c. hearing
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#28 Movement of snakes include all EXCEPT
a. lateral undulation
b. rectilinear movement
c. concertina movement
d. inch worm

#29 Crocodilians are unique reptiles due to ...
a. oviparity
b. four chambered heart
c. cerebral cortex
d. both B and C

#30 Some European lizards may develop from unfertilized eggs, called ...
a. prehensile
b. parthenogenesis
c. plastron
d. carapace

#31 Which are not classified within Suborder Sauria?

a. komodo dragon
b. geckos
c. iguana
d. turtles

#32 Sea turtle eggs depend on ____ to determine sex of offspring.
a. time of nesting
b. place of nesting
c. temperature of nest
d. amount of minerals in nest

#33 The chameleon can change its color based on
a. mood
b. environment
c. season
d. diet

#34 Plates covering a turtle's shell are called ....

a. carapace
b. plastron
c. scutes
d. scales

#35 Similarities between alligators and crocodiles include all EXCEPT
a. oviparous
b. narrowness of snout
c. carnivores
d. four chambered heart

#36 Which temperature ranges will bear female alligator young?

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b. higher than 86 F
c. lower than 93 F
d. higher than 93 F

#37 Unique heat sensor for snakes is called the ....
a. elapid
b. pit
c. Jacobson's organ
d. sacral vertebrae

#38 Feature of reptiles that are more "advanced" than amphibians include all EXCEPT
a. respiration
b. excretory
c. nervous
d. digestion

#39 The dorsal shell of a turtle is called __.

A. carapace
B. pectoral girdle
C. plastron
D. scutes

#40 Prehensile means to ...

a. live in a primitive time
b. regeneration
c. development of unfertilized egg
d. wrap around limbs

#41 According to diagram, the yolk sac is labeled

A) A
B) B
C) C
D) D
E) E
F) F

#42 According to the diagram, the allantois is labeled

A) A
B) B
C) C
D) D
E) E
F) F

#43 According to the diagram, the amnion is labeled

A) A
B) B
C) C
D) D
E) E
F) F

#44 SLIDE ONE

Ventricle is .....

A) A
B) B
C) C
D) D
E) E

#45 SLIDE ONE

Liver is .....

A) A
B) B
C) C
D) D
E) E

#46

SLIDE ONE

Lung is .....

A) A
B) B
C) C
D) D
E) E

#47

SLIDE TWO

Gallbladder is .....

A) A
B) B
C) C
D) D

#48

SLIDE TWO

Ventricle is .....

A) A
B) B
C) C
D) D

#49

SLIDE THREE

Testes is .....

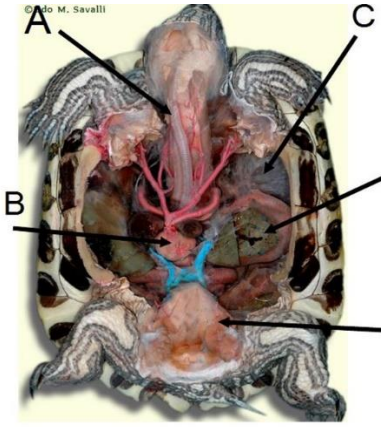
A) A
B) B
C) C
D) D

#50

SLIDE THREE

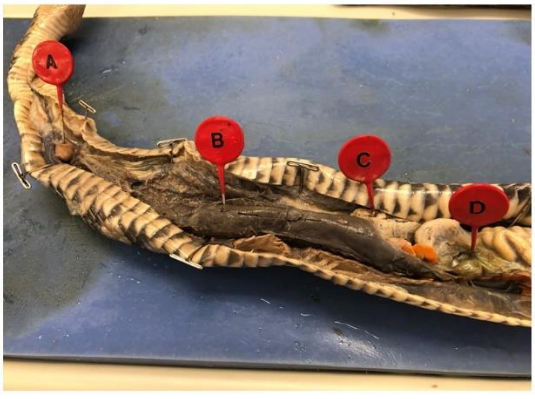
Kidney is .....

A) A
B) B
C) C
D) D

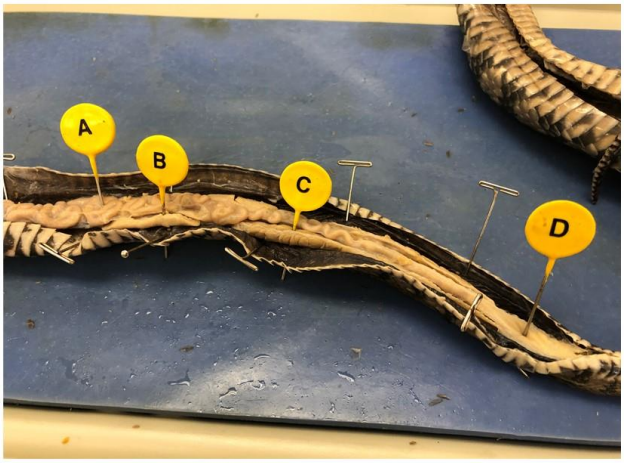


SLIDE ONE

SLIDE TWO



SLIDE THREE



Name: Class: Date:

#1 Which of the following is NOT a characteristic of birds?

A) flight
B) four chambered heart
C) endothermic
D) hard shelled eggs

#2 In regards to reproduction, most birds can be described as ....

a. monogamous
b. polygamous
c. asexual
d. hermaphroditic

#3 Requirements for flight include all EXCEPT...

a. feathers
b. light bones
c. high metabolic rate
d. small keel

#4 Young offspring that are featherless and require parental help in feeding are described as ...

A. altricial
B. precocial
C. asexual
D. mongamous

#5 Types of feathers include all EXCEPT

a. contour
b. down
c. filoplumes
d. preen

#6 A bird's respiratory system is more advanced than a reptile's system due to ....

A. keel
B. feathers
C. air sacs
D. homeothermy

#7 Feather structures include all EXCEPT

A) barbs
B) quill
C) shaft
D) crop

#8 Beginning portion of digestive tract where food may be temporarily stored is called the...

A. proventriculus
B. crop
C. gizzard
D. liver

#9 A set of eggs is called ...

A) clutch
B) dozen
C) brood
D) litter

#10 A spiral rope-like strand that anchors the yolk in a bird's egg is called ...

A) albumin
B) allantois
C) chorion
D) chalaza

#11 Additional attachment for flight muscles is provided by the ...

A) sternum
B) keel
C) cerival vertebrae
D) furcula

#12 Lift for flying is provided by ...

A) primary flight feathers
B) secondary flight feathers
C) tail feathers
D) cover feathers

#13 The vertebrae of a bird that are fused and therefore, nonmoving, is ...

A. neck
B. thoracic
C. abdominal
D. pelvic

#14 The adaptation that compensate for the lack of teeth in birds is ...

A) gizzard
B) keel
C) air sacs
D) sharp beak

#15 Another name for the shaft of a feather is ...

A) filoplume
B) bristle
C) rachis
D) quill

#16 Adaptations for flight include all EXCEPT

A) hollow bones
B) fused thoracic vertebrae
C) air sacs
D) long legs

#17 The wing bones of birds comprise all EXCEPT

A) humerus
B) radius
C) femur
D) ulna

#18 All the feathers of a bird are collectively called ...

A) plumage
B) molting
C) integumentary system
D) syrinx

#19 The embryo is surrounded by a protective sac called ...
a. chorion
b. amnion
c. allantois
d. shell membrane

#20 Birds most likely arose as an early branch of the _____ group.
a. amphibian
b. reptile
c. mammal
d. fish

#21 A special feature of birds' bones, they are filled with ...
a. blood
b. air
c. feathers
d. fluid

#22 Largest muscle that depresses the wings is called ...
a. supracoracoideus
b. pectoralis
c. tendon
d. cardiac

#23 A type of feather that resemble fine hair with shaft ending in a few barbs is ....
a. contour
b. bristles
c. filoplumes
d. down

#24 The part of the feather that is embedded into the flesh of a bird is ...
a. shaft
b. barb
c. quill
d. barbules

#25 *Archaeopteryx* is a fossil with several birdlike features including all EXCEPT
a. feathered body
b. conical teeth
c. light-weight
d. feathers on wings

Name: Class: Date:

#1 Fledglings that follow their parents soon after hatching and can feed themselves are described as ...
a. altricial
b. precocial
c. monogamous
d. hermaphroditic

#2 Birds reproduce by _____ fertilization.

a. internal
b. external
c. parthenogenesis
d. asexual

#3 Modern birds may be described as ...

a. homeothermic
b. ectothermic
c. endothermic
d. both a and c

#4 Birds are classified within Orders based on ....

a. beak and foot types
b. color of feathers
c. length of feathers
d. how far they migrate

#5 In birds, the _____ is large, providing an attachment site for flight muscles.
a. pectoralis
b. tendon
c. keel
d. wings

#6 The center part of a feather is called the ...

a. quill
b. shaft
c. barbs
d. barbules

#7 Branching from the barbs on a feather are the ...

a. quills
b. shafts
c. barbs
d. barbules

#8 Feathers that act as a balancing tool during flight for pigeons are ...

A) tail feathers
B) primary feathers
C) secondary feathers
D) cover feathers

#9 The most prominent digit on the forelimbs or wings of birds is ...

A) digit one
B) digit two
C) digit three
D) digit four

#10 Another name for the "wishbone" in a bird is ...

A) sternum
B) keel
C) furcula
D) cervicals

#11 Gulls and terns are classifed within Order ...

a. Sphenisciformes
b. Ciconiiformes
c. Charadriiformes
d. Gruiformes

#12 Owls are classified within Order ....

a. Piciformes
b. Falconiformes
c. Strigiformes
d. Pelecaniformes

#13 The brown pelican is classified within Order ...

a. Piciformes
b. Falconiformes
c. Strigiformes
d. Pelecaniformes

#14 Woodpeckers and toucans are classified within Order ...

a. Charadriiformes
b. Gruiformes
c. Piciformes
d. Falconiformes

#15 Herons, egrets, storks, ibises, spoonbills and famingos are all classified within Order ....
a. Sphenisciformes
b. Ciconiiformes
c. Charadriiformes
d. Gruiformes

#16 Cranes, such as the MS Sandhill Crane is classified within Order ...

a. Sphenisciformes
b. Ciconiiformes
c. Charadriiformes
d. Gruiformes

#17 Penguins are classified within Order ...

a. Sphenisciformes
b. Ciconiiformes
c. Charadriiformes
d. Gruiformes

#18 All of the following are classified within Order Falconiformes EXCEPT

A) red tail hawk
B) cooper's hawk
C) cranes
D) bald eagle

#19 Our least endangered species of bird is ...

A) frigatebird
B) red cockaded woodpecker
C) bald eagle
D) MS sandhill crane

#20 Young pigeons may be distinguished from older pigeons by ...

A) size
B) color of feathers
C) color of eyes
D) color of feet

#21 A young pigeon from one to thirty days old is called a ...

A) fledgling
B) juvenile
C) squab
D) peeper

#22 The heart is surrounded by a thin, translucent, fibrous sac called the ...

A) atrium
B) ventricle
C) pericardium
D) vena cava

#23 Two tiny white sac-like structures, intestinal caecae, function includes

A) storage of wastes
B) applies shell covering for eggs
C) water regulation
D) microorganisms to break down food

#24 The upper part of the stomach is called the ...

A) proventriculus
B) ventriculus
C) crop
D) gizzard

#25 The tube that leads to the cloaca from the kidneys is called the ...

A) urethra
B) ureter
C) teste
D) vas deferens

Name: Class: Date:

#1 Characteristics of Class Aves includes all EXCEPT

A) 4 chambered heart
B) feathers
C) homeothermic
D) soft, leathery egg

#2 All are classified within Order Strigiformes EXCEPT

A) horned owl
B) bald eagle
C) barred owl
D) spotted owl

#3 Hawks, our school mascot is classified within Order ...

A) Sphenisciformes
B) Ciconiformes
C) Piciformes
D) Falconiformes

#4 Benefits of air sacs include all EXCEPT

A) oxygen rich and oxygen poor air mixes
B) increases amount of oxygen in body
C) more efficient cell respiration
D) more energy available for bird

#5 Parts of egg include all EXCEPT

A) albumin
B) chalaza
C) yolk
D) scales

#6 Feather structures include all EXCEPT

A) barbs
B) quill
C) shaft
D) crop

#7 Characteristics of Class Aves includes all EXCEPT

A) air sacs
B) teeth
C) endothermic
D) wings

#8 Adaptations for flight include all EXCEPT

A) large pectoralis muscle
B) keel for muscle attachment
C) hollow bones
D) small veins

#9 Gulls and terns are classified within Order ...

a. Sphenisciformes
b. Ciconiiformes
c. Charadriiformes
d. Gruiformes

#10 In regards to reproduction, most birds may be described as ....

a. monogamous
b. polygamous
c. asexual
d. hermaphroditic

#11 Young pigeons may be distinguished from older pigeons by ...

A) color of beak
B) color of feathers
C) color of eyes
D) color of feet

#12 The vertebrae of a bird that are fused and therefore, nonmoving, is ...

A. neck
B. thoracic
C. abdominal
D. pelvic

#13 Passenger pigeons went extinct due to ...

A) building of railroad
B) other exotic species competed them to extinction
C) hawks and eagles
D) humans

#14 All of the following are classified within Order Falconiformes EXCEPT

A) red tail hawk
B) cooper's hawk
C) cranes
D) bald eagle

#15 The most prominent digit on the forelimbs or wings of birds is ...

A) digit one
B) digit two
C) digit three
D) digit four

#16 The brown pelican is classified within Order ...

a. Piciformes
b. Falconiformes
c. Strigiformes
d. Pelecaniformes

#17 Beginning portion of digestive tract where food may be temporarily stored is called the...

A. proventriculus
B. crop
C. gizzard
D. liver

#18 Herons, egrets, storks, ibises, spoonbills and famingos are all classified within Order ...
a. Sphenisciformes
b. Ciconiiformes
c. Charadriiformes
d. Gruiformes

#19 Function of intestinal caecae include ...
A) storage of wastes
B) temporary storage of bile
C) salt regulation
D) microorganisms to break down food

#20 Another name for the "wishbone" in a bird is ...

A) sternum
B) keel
C) furcula
D) cervicals

#21 Our state's LEAST endangered species of bird is the ...
A) red tail hawk
B) red cockaded woodpecker
C) interior least tern
D) sandhill crane

#22 Largest muscle that depresses the wings is called ...
a. supracoracoideus
b. pectoralis
c. tendon
d. cardiac

#23 Parts of the digestive system include all EXCEPT

A) ventriculus
B) gizzard
C) crop
D) pericardium

#24 Transitional fossil animal between reptiles and modern birds is the ...

A) Titaliik
B) Archaeopteryx
C) Amphibia
D) Vilocoraptor

#25 A set of eggs is called a ...

A) clutch
B) dozen
C) brood
D) litter

#26 A type of feather that resemble fine hair with a few barbs near the base of shaft is called ...
a. contour
b. bristles
c. filoplumes
d. down

#27 The tube that leads to the cloaca from the kidneys is called the ...

A) kidneys
B) ureters
C) testes
D) vas deferens

#28 Birds reproduce by _____ fertilization.

a. internal
b. external
c. parthenogenesis
d. asexual

#29 Branching from the shaft on a feather are the ...

a. quills
b. shafts
c. barbs
d. barbules

#30 Types of feathers include all EXCEPT
a. contour
b. down
c. filoplumes
d. preen

#31 Young offspring that are featherless and require parental help in feeding are described as ...
A. altricial
B. precocial
C. asexual
D. mongamous

#32 A spiral rope-like strand that anchors the yolk in a bird's egg is called ...
A) albumin
B) allantois
C) chorion
D) chalaza

#33 Additional attachment for flight muscles is provided by the ...
A) sternum
B) keel
C) cerival vertebrae
D) furcula

#34 The adaptation that compensate for the lack of teeth in birds is ...
A) gizzard
B) keel
C) air sacs
D) sharp beak

#35 All the feathers of a bird are collectively called ...
A) plumage
B) molting
C) integumentary system
D) syrinx

#36 **What is a "swan song"?**
A. mating call
B. warning others
C. dying song
D. finding food

#37 **What does it mean "to eat like a bird"?**
A. only eat small amounts
B. only eat vegetables
C. consume large amounts of food
D. peck at your food

#38 **How is "water off a duck's back" possible?**
A. swims very fast
B. oil from preening gland
C. narrow feathers
D. small body

#39 Birds are classified within Orders based on ....
a. beak and foot types
b. color of feathers
c. length of feathers
d. how far they migrate

#40 Fledglings that follow their parents soon after hatching and can feed themselves are described as ...
a. altricial
b. precocial
c. monogamous
d. hermaphroditic

#41 Branching from the barbs on a feather are the ...
a. quills
b. shafts
c. barbs
d. barbules

#42 SLIDE ONE
Crop is .....
A.
B.
C.
D.
E.

#43 SLIDE ONE
The pin labeled, B, is the?
A) trachea
B) crop
C) ventriculus
D) rectum

#44 SLIDE ONE
The pancreas is ...
A.
B.
C.
D.
E.

#45 SLIDE TWO
Which pin is the intestinal cecae?
A.
B.
C.

#46 SLIDE TWO

Which pin is the testes?

A.
B.
C.

#47 SLIDE THREE

The green material found in this organ is....
A. bile
B. feces
C. hemolymph
D. urine

#48 SLIDE FOUR

Which pin is the keel?

A.
B.
C.

#49 SLIDE FIVE

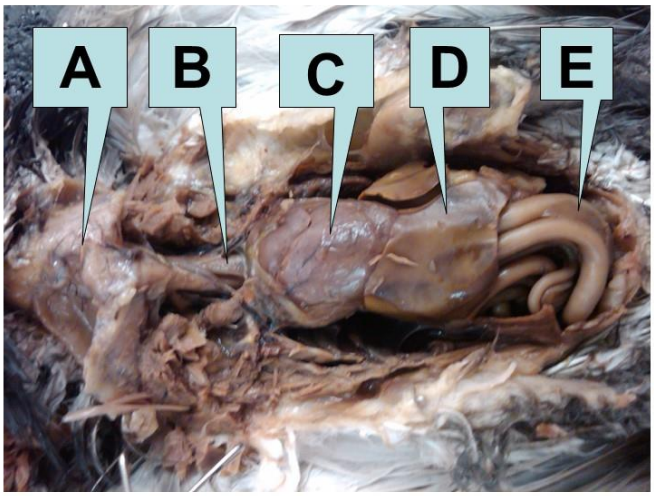
Which label is the lung?

A.
B.
C.

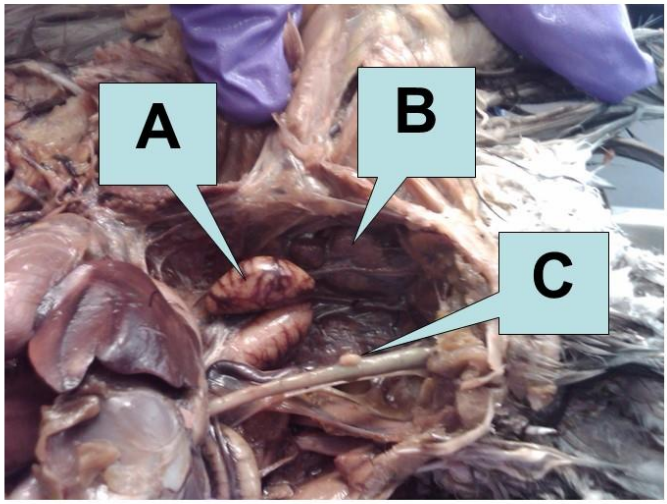
#50 SLIDE FIVE

Which label is the ovary?

A.
B.
C.



SLIDE ONE



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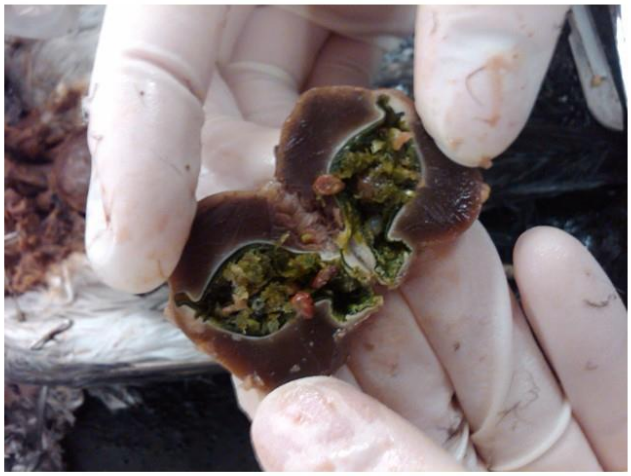

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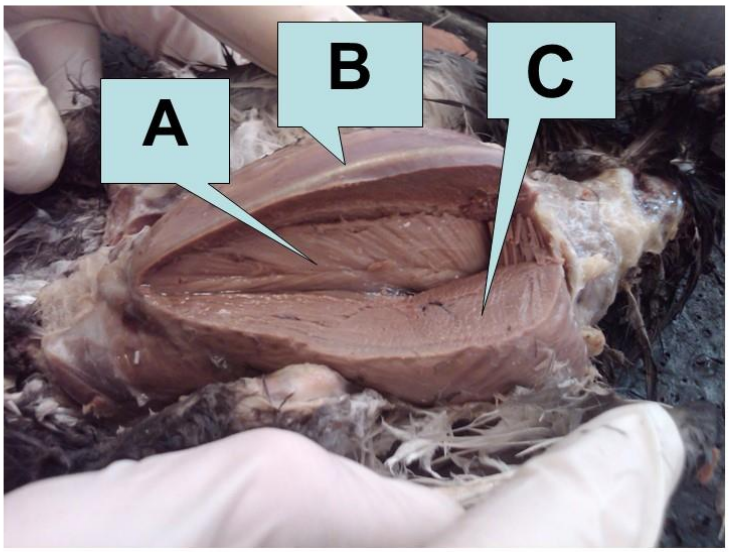
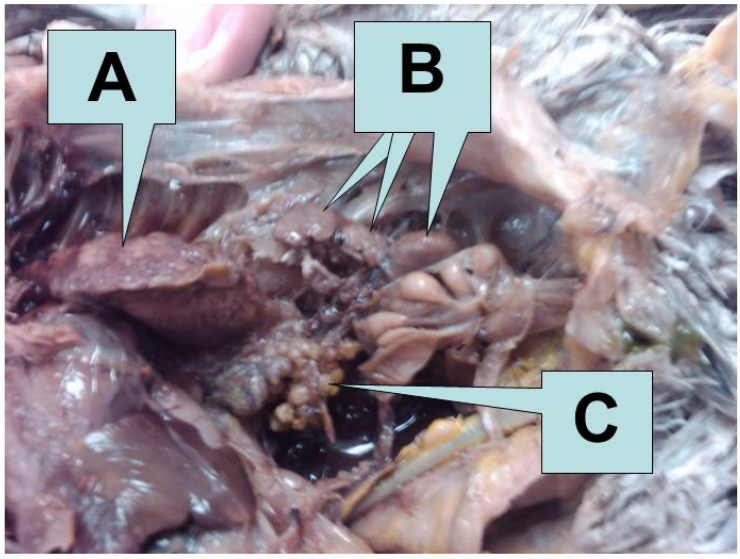


SLIDE FOUR



SLIDE FIVE

Name: Class: Date:

#1 Flying mammals are classified within ....

a. Order Monotreme
b. Order Sirenia
c. Order Carnivora
d. Order Chiroptera

#2 Mammals with a pouch are classified within ....

a. Order Montreme
b. Order Carnivora
c. Order Marsupial
d. Order Sirenia

#3 Insect eating mammals, moles, shrew, hedgehogs are classified within ....
a. Order Monotreme
b. Order Chiroptera
c. Order Insectivora
d. Order Carnivora

#4 Mammals whose embryo remain in the uterus and is nourished by mother by way of placenta are called ...
A. homeotherms
B. eutherians
C. oviparous
D. marsupials

#5 Egg laying mammals, spiny anteater, duckbill platypus are classified within .....
a. Order Monotreme
b. Order Marsupial
c. Order Chiroptera
d. Order Carnivora

#6 Young marsupials are called ....

A. pups
B. joeys
C. infants
D. squabs

#7 Mammal that utilizes echolocation includes the

A. bats
B. primates
C. marsupials
D. squabs

#8 Mammals that possess vemon includes all EXCEPT
A. duckbill platypus
B. echnida
C. shrew
D. mole

#9 Another name for the spiny anteater is ...

A. solenodon
B. echnida
C. shrew
D. mole

#10 Echidna may be found in all areas EXCEPT
A. Australia
B. Tasmania
C. New Guinea
D. South America

#11 The marsupial that is found in our area is ...

A. ant eater
B. bat
C. armadillo
D. opossum

#12 Tasmanian devil is unique due to ...
A. marsupial
B. strongest jaws of mammals
C. has 15 offspring
D. ectothermic

#13 When young is nourished is by umbilical cord to receive nutrients from mother during gestation, it is referred to as...
A. oviparity
B. ovoviviparity
C. viviparity
D. asexual reproduction

#14 All mammals share these characteristics EXCEPT
A) vertebrates
B) hair or fur during some time in life
C) mammary glands
D) placenta

#15 Another name for homeothermic is ...

A) ectothermic
B) endothermic
C) exothermic
D) homeostasis

#16 Type of reproduction found within Class Mammalia include all EXCEPT

A) oviparity
B) ovoviviparity
C) viviparity

#17 Having two sets of teeth are described as ...

A) monophoyodont
B) diphoyodont
C) triphoyodont
D) heterophoyodont

#18 All are marsupials EXCEPT

A) bat
B) opposum
C) kangaroo
D) koala bear

#19 Conditions at birth include all EXCEPT

A) can run, with fur
B) can reproduce immediately
C) blind and hairless
D) blind with hair

#20 The duckbilled platypus lays eggs, but also feed it young _____, and therefore it is a mammal.

A) water
B) plants
C) meat
D) milk

#21 Marsupials leave their mother's womb and then enter her ____ to complete their development.

A) mouth
B) uterus
C) pouch
D) den

#22 Marsupials are born _____.

A) once
B) twice
C) fully developed
D) ready to feed

#23 Order Insectivora includes all EXCEPT

A) moles
B) hedgehogs
C) ant eater
D) shrews

#24 Which is not an insectivore?

A) pigs
B) mole
C) anteaters
D) bats

#25 Which characterization about gestation is true with mammals?

A) the larger the mammal, the shorter the gestation
B) the larger the mammal, the longer the gestation
C) the smaller the mammal, the longer the gestation
D) there is no pattern at all

Name: Class: Date:

#1 Smallest Order of mammals in relationship to diversity is Order ...
A) Pinnipedia
B) Rodentia
C) Primates
D) Proboscidea

#2 Which "drops" after the breeding season?
A) horns
B) antlers
C) whiskers
D) bristles

#3 All are classified within Order Perissodactyla EXCEPT
A) zebras
B) tapirs
C) deer
D) horses

#4 Order Rodentia includes the following mammals EXCEPT
A) rats
B) squirrels
C) rabbits
D) woodchucks

#5 Modifications of hair include all EXCEPT
A) bristles
B) spines
C) whiskers
D) tusks

#6 Water dwelling mammals are classified within the following Orders EXCEPT
A) Sirenia
B) Edentata
C) Pinnipedia
D) Cetacea

#7 Molting can occur ___ often during the year.
A) once
B) twice
C) three times
D) all of the above

#8 Water dwelling mammals with no hind limbs, manatees are classifed within ....
a. Order Sirenia
b. Order Cetacea
c. Order Pinnipedia
d. Order Primates

#9 Types of glands include all EXCEPT
A) sweat
B) scent
C) antlers
D) sebaceous

#10 The practice of eating own fecal matter to obtains vitamins, such as rabbits, is called ...
A) browers
B) coprophagy
C) omnivores
D) saphrotrophs

#11 Ultrasound (sonar) is utilized by the following mammals EXCEPT
A) bats
B) dolphins
C) whales
D) manatees

#12 Some mammals have different types of teeth for different tasks, described as being ...
A) homodont
B) heterodont
C) diphoyodont
D) monphoyodont

#13 Parts of the hair include all EXCEPT
A) tusks
B) medulla
C) cuticle
D) cortex

#14 Order Insectivora includes the following mammals EXCEPT
A) moles
B) rats
C) shrews
D) hedgehogs

#15 Another name for Order Endentata is ...
A) Chiroptera
B) Xenarthra
C) Lagomorpha
D) Cetacea

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D) Cetacea

#16 Type of teeth utilized for mastication (grinding) is ...

A) canine
B) incisors
C) premolars
D) molars

#17 Which accessory is composed of two parts?

A) antlers
B) horns
C) tusks
D) bristles

#18 Differences among the water dwelling mammals that place them in different orders is ...

A) where they live
B) fresh or saltwater
C) number of limbs and body shape
D) types of limbs

#19 Trunk nosed mammals, elephants are classified within Order ...

A) Endenata
B) Probocidea
C) Perrissodactlya
D) Lagomorpha

#20 Trunk nosed mammals, elephants are classified within Order ...

A) Endenata
B) Probocidea
C) Perrissodactlya
D) Lagomorpha

#21 Flesh eating, dogs, wolves, cats, bears, weasels are classified within Order ...

A) Marsupial
B) Insectivora
C) Chiroptera
D) Carnivora

#22 Water dwelling carnivores, sea lions, seals and walrus are classified within Order ...

A) Sirenia
B) Cetacea
C) Pinnipedia
D) Primates

#23 Even toed ungulates, swine, camels, deer, antelope, cattle, sheep, goat are classified within Order ...

A) Monotreme
B) Perissodactyla
C) Artiodactyla
D) Insectivora

#24 Type of teeth that are utilized for piercing and arc long conical teeth are called ...

A) molar
B) premolar
C) incisors
D) canine

#25 Horn that is constructed from hairlike fibers cemented together is called ...

A) tusk
B) true horn
C) antler
D) rhinoceros horn

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